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CONTENTS:

	PAGE
Equaliser Systems of Distribution	159
Traction Diagrams (*illustrated*) (*continued*)	161
Long Distance Transmission	163
Transmission of Power in Mines	164
New Lamps for Old (*illus.*)	166
On Alternating Current Rushes in Condensers (*illus.*) (*concluded*)	168
The Hess-Raverot-West System of Telephone Exchanges (*illus.*)	169
Lightning Express Railway Service (*illustrated*)...	173
Fuel Problems	175
Experiments on the Latent Heat of Steam	176
Some Curious Fires caused by Electricity	177
Correspondence:—	
Johnson & Phillips's Arc Lamp	177
Business Notices, &c....	178
Electric Lighting Notes	179
Electric Traction and Motive Power Notes	180
Telegraph and Telephone Notes	180
Contracts Open and Closed	181
Notes	181
City Notes	182
Traffic Receipts	183
Share List of Electrical Companies	184
Alternate Current Transformers.—III. (*illustrated*)	185
Wages and Hours of Labour	189
New Patents	189
Abstracts of Published Specifications	190

THE

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EQUALISER SYSTEMS OF DISTRIBUTION.

THE three-wire system is now very largely used, but in only a few of its many practical examples are two generators run in series with three conductors led away from them to the area of supply. Motor-compensator or balancing dynamotors, secondary batteries, and other devices have been imported into low-tension stations, and the simple Edison or Hopkinson arrangement has been so elaborated that it can no longer be described under the terms employed by these inventors in their patents. We referred to this growth and steady development when describing the King's Road generating station and Highgate balancing sub-station of the Vestry of St. Pancras, and there briefly indicated what Prof. Robinson and his assistants had done to extend the range of a low-pressure supply.

It may be of some interest to sketch the proposals that have been made with reference to equalisers, compensators, or balancers. One of the difficulties of balancing on a three-wire system, that due to the resistance of the mains when a compensator and one generator only are used, was mentioned in our article on the Burnley station a year or two ago, and in the correspondence that was called forth by it, several writers went fully into the practical questions that have to be met by an engineer in working a small station of the kind.

The three-wire system can be eliminated by reverting to a single 200-volt dynamo with the lamps of 100 volts connected, two in series, with an intermediate conductor joining the junctions; but this antiquated device, used, we would not like to say how many years ago, and adopted by Brush in some of his earlier series-parallel arrangements, would not give much satisfaction nowadays. A single dynamo, with two armature windings, and a double set of commutators, might also be considered; but here we are met by a special construction, and twice the amount of attention being required that ought otherwise to be necessary. Then there is the Fives-Lille arrangement of an inductive coil, wound in the armature, with its ends connected to two diametrically opposite points on a Gramme ring, and the third wire brought to its centre and teed on. This does not strike one as giving the solution.

Next we come to a generator on the outers, with a small balancing machine connected across the more heavily loaded side. The balancer might be driven by a motor if thought worth while, or even two small machines for balancing might be employed as in earlier practice. The former of these two proposals has been largely adopted, and seems to be as satisfactory a way as any, only the driving motor in this country is more frequently a steam engine rather than one operated by current taken from the outer conductors. The use, however, of a 200-volt motor and two balancing machines driven from it, presents some theoretical advantages which are

practically realised in the now well-known practice of running a motor-generator across the three wires. This dispenses with the driving motor, and is the equivalent of coupling the two balancing machines rigidly together. These are then coupled in series, and the third wire is taken to the intermediate point, while the fields are excited across the outers.

For feeder compensation, motor-generators have been used in this country and on lighting circuits by Sayers, and in the United States for electric traction work by J. H. Vail. Again, motor-generators with continuous current supply and alternating current output have been put into service at Sunderland and Brighton, so that their uses are manifold, and they seem to be doing as much for central station engineers as the advocates of the storage battery held that secondary cells could and would do when they were given a fair field.

The secondary battery, as an equaliser, has done and is doing very good work. Witness its use on lighting circuits, either where motor equalisers have not yet been obtained or in addition to them, and its rather newer field in traction work, where, if it cannot perhaps as yet be conceded to be an unqualified success on the cars themselves, it at least fulfils a useful function by supplying power from a sub-station.

In fine, equalisers and motor-generators are essentially the result of demand on the part of the electrical engineer for engineering appliances. The engineer has at last succeeded in bringing the electric motor into the position of being an appliance that can be depended on and maintained with reasonable care and attention. He therefore calls upon it to take up many tasks in the central station, which it is now admirably fitted for, and in each step we see the growth of the supply station from an electrician's work towards that of the engineer, to whom running machinery is the best type of regulating plant.

A Self-Cooling Condenser.

A NEAT arrangement of the self-cooling condenser was described in a paper by Mr. Alberger, before the May meeting of the American Society of Mechanical Engineers. One may still hear the excuse made for not securing the advantages of condensation, on the ground that there is no condensing water available, whereas the facts are that condensing, when carried out with suitable cooling apparatus, actually calls for less total supply of water than non-condensing working. In the apparatus described by Mr. Alberger, an engine of 1,000 horse-power only requires a space of 17 feet diameter by 30 feet high. The apparatus consists of a cylindrical shell of plate, open at the top. Near the base is a grating; on this grating are stood in layers a filling of cylindrical tiles, 24 inches long by 6 inches diameter, so packed as not to form continuous tubes, but one tile rests on several of those below it. Air is blown by a fan below the grating, and water is distributed over the top of the tower by a kind of Barker's reaction mill. Thorough breaking up of the air and water is effected by the many divisions of the tiles. A vacuum of 24 inches and upwards may be obtained, and a supply of 2,000 gallons of water is enough to start with in case of a 1,000 H.P. plant, this stock gradually growing larger, and enabling the supply of fresh water to be actually less than the amount of steam used by the engine, for the cooling effect is partly secured by radiation, and only the portion effected by vaporisation of the water causes loss of water. The feed water of a non-condensing engine is thus greater than the supply of water for a condensing engine of equal power. The power absorbed by the fan will not exceed an average of $1\frac{1}{4}$ per cent. of the main engine power the year round, and generally the total power absorbed by the condensing department does not exceed 5 per cent. of the main engine power. The increased efficiency of area obtained by the system, probably a hundredfold, is such as to bring condensation within reach of very many places hitherto run non-condensing. Both coal and water may, in fact, be saved in this manner, and there is no excuse for not condensing where room is available for such a system. The same remark will apply to the evaporative condenser, which, however, is simply the same system applied to surface condensation, and we do not know any instance of this type having been fitted with a fan to ensure air movement.

Automatic Coal Weighing for Power Stations.

THOUGH he discusses the question of automatically weighing coal in a recent American paper, Mr. F. H. Richards does not give any information as to the construction of machines, yet if they could be conveniently applied they would be exceedingly valuable as continuous checks upon the efficiency of men and plant. The late Eckley B. Coxe once said that he did not so much care to know what his steam plant could do, as what it was being made to do day by day, and there can be little doubt but that the widely published test to three places of decimals has next to no practical value. To know what a boiler is doing day by day, means the measuring of the coal and water, and both these articles must be measured continuously, and, of course, automatically, in order that the cost may be less than the gain likely to accrue from the possession of the records. Mr. Richards would dry all coal and automatically weigh it to store, and again weigh out to the boilers. Few people are aware of the large use made of automatic weighing machines in many trades—notably in the parcelling out of food products, and there is no reason why similar machines should not parcel out fuel. Though accuracy is desirable, it would be sufficient for many purposes to know how many parcels of coal were weighed off in a given time, so long as the parcels were alike. An error in each of a few pounds would matter nothing so long as the ratio of coal parcels to the water meter reading was capable of being known day by day. Automatic coal weighing should be much more easily dealt with, however, in American practice than with us. Carefully graded sizes of hard coal or anthracite are much used in America, and the difficulties which come along with different sizes do not exist. The use of terms such as pea-coal, buckwheat, rice, &c., conveys some idea of the system of assortment practised with anthracite coal, and we believe this assortment is almost necessary because of the difficulty in burning anthracite when particles of a different size get together in a furnace. A uniform size of particle enables a fire to be made level and even and to burn evenly, and automatic weighing obviously is greatly facilitated by such grading of fuel.

Fires Caused by Electricity.

MUCH instruction is to be gained by a perusal of the short article on this subject which appears in another part of this issue. There is little doubt that if electrical work is badly done trouble will arise sooner or later. But though the number of fires caused in America reaches an inordinately high figure, there is no reason why they should increase and multiply here, and we trust that the wiring contractor will be wise in time. Above all we hope that all fire offices will see that their inspectors are able to detect inferior workmanship, and will on all occasions make a strong stand against the dangerous class of wiring that abounds.

TRACTION DIAGRAMS.

By THOMAS TOMLINSON, B.E.

(*Continued from page* 131.)

Having now obtained the mean drawbar pull necessary to overcome the combined effect of friction, grades, and starts, it remains to get mean speed in order to get mean power.

Let v be the velocity in feet per second of a tramcar between two points, L and M, connected by a dead level road, the run to be made without stops and with a flying start: let v_1 be the velocity in feet per second necessary to traverse the distance between two points the same horizontal (or map) distance apart, but over a graded line; the run to be again made without stops and with a flying start: let v_2 be the maximum velocity in feet per second necessary to traverse the graded line in the same time when $(n - 1)$ intermediate stops and starts are made on the way, or n stops and n starts including start at L, and final stop at M: let t_1 be the average time in seconds from cutting off current to stop, and t_2 be the time in seconds from start to full speed: let l be the horizontal distance between L and M, and let l_1 be the surface distance: then

$$\frac{l}{v} = \frac{l_1}{v_1} \qquad (1)$$

and

$$\frac{l_1}{v_1} - \frac{l_1}{v_2} = \frac{n}{2}\left(t_1 + t_2\right).$$

The ratio v_1 to v is got once for all from the line section; but the relation between v_1 and v_2 depends on the four quantities l, n, t_1, and t_2: these four would be known in any given case, and also either v_1 or v_2, *i.e.*, either the limiting speed or the mean speed; hence from equation (2) we can determine the unknown velocity.

For instance, in our case, $l_1 = 15{,}171'$, $n = 14$, $t_1 = 10$ seconds, $t_2 = 20$ seconds, and $v_2 = 15$ feet per second, whence $v_1 = 12{\cdot}4$ feet per second.

Now, equation (2) simply expresses the fact that v_1 is the mean speed of the run under conditions of uniform acceleration over 20 seconds from rest to full speed (v_2) and uniform retardation over 10 seconds from full speed (v^2) to rest at each of n starts and stops.

We may, therefore, in all questions of mean power, use v_1 as the speed factor after we have used v_2 to determine the mean drawbar pull necessary for acceleration.

The mean power per ton (measured at the car axles) for the case we are considering is, therefore, $12{\cdot}4\ (25 + 10 + 3{\cdot}4)$ foot-pounds per second = 476 foot-pounds per second = 0·86 B.H.P.

This is simpler, and admits of much easier comparison between different lines, than the form in which mean power per ton would appear using v_2 for full speed, and $\frac{v_2}{2}$ during acceleration and retardation with the appropriate values for mean drawbar pulls. In our case, mean power per ton, if expressed in the latter form, would be :—

$$\frac{12{,}021' \times 35 \times 15 + 2{,}100' \times 77{\cdot}5 \times 7{\cdot}5 - 1{,}050 \times 35 \times 7{\cdot}5}{15{,}171}$$

foot-pounds per second, which gives 478 foot-pounds per second.

The tramline we have taken as an example has, as a matter of fact, no sharp curves, and we are now in a position to calculate and tabulate figures giving mean speed, maximum speed, mean power, and maximum power, for a double run between L and M. These figures will vary according as the line is level or graded, and as the run is made (1) without stops, (2) with 14 stops, (3) with 28 stops. The same time is, in all cases, taken for the run, this time being that which gives an average speed v_1 of 12·4 feet per second. For convenience take $v = v_1$: the resulting figures are given below.

The figures are instructive as showing the influence of grade and stops, though it is obvious that the 28 stops lead to a maximom speed (19 feet per second, say nearly 13 miles per hour) which, under the conditions of traffic which would give so many stops, would be impossible; even if it were not so tremendously costly in power.

In general, so many stops per mile (8) would only occur on part of a line—as, say, at the city end of a line stretching out to the suburbs; the American practice in such a case, and the correct one, is to run the city end at a low rate of speed, and to greatly increase this rate in the suburbs. In making calculations for a line to be run on this plan it would be necessary to divide it into two parts, each subject to its own conditions as to speed and stops.

	Mean drawbar pull in lbs. per ton.	Relative values of mean drawbar pulls.	Mean speed in feet per second.	Mean power per ton in foot lbs. per second.	Relative values of mean powers.	Maximum drawbar pull in lbs. per ton.	Relative values of maximum drawbar pulls.	Maximum speed in feet per second.	Relative values of maximum speeds.	Maximum power per ton in foot lbs. per second.	Relative values of maximum power.
Level line, no stops ...	25·0	100	12·4	310	100	25 0	100	12·4	100	310	100
Graded line, no stops ..	35·0	140	"	434	140	118·3	473	12·4	100	1,466	473
Level line, 14 stops ...	30·5	122	"	378	122	77·5	310	15·0	121	1,162	375
Graded line, 14 stops ...	38·4	154	"	476	154	170·8	683	15 0	121	2,562	826
Level line, 28 stops ...	44 0	176	"	545	176	91 5	366	19 0	153	1,738	560
Graded line, 28 stops ...	48·6	195	"	603	195	184 8	739	19·0	153	3,511	1,132

Effects of Grade on Central Station Economy.

To investigate this we take our drawbar pull diagrams, figs. 3 and 4, and cut them each into lengths equal to the distance between cars (as due to mean speed and headway); in this case we take four lengths giving a headway of $\frac{3{,}800}{12{\cdot}4}$ seconds, say 5 minutes. We place them one under the other as in figs. 8 to 15, of which figs. 8 to 11 represent the four sections of fig. 3 from left to right, and figs. 12 to 15 represent the four sections of fig. 4 from right to left. In the latter case the diagrams are placed so that the right of each section in fig. 4 is placed to the left in figs. 12 to 15—as will be obvious by inspection. I have increased the length of the sections 3 and 4 by 30 feet, so as to have the beginning and end of every figure at an even hundred mark.

If we now imagine eight cars to start simultaneously from the left of all the sections shown in figs. 8 to 15 with flying starts, and each to traverse its own section at the mean speed (12·4 feet per second), then the sum of the drawbar pulls at corresponding points on all the sections, multiplied by 12·4 feet per second, represents (at the car axles) the total demand upon the central station for every 8 tons moved in foot pounds per second, when eight cars, four in each direction, are moving upon the tram line with constant velocity (12·4 feet per second) without stops.

The resulting diagram is fig. 16, which represents the variations in power (speed being constant) at car axles, which has to be supplied from the central station as the effect of grades alone.

The diagram is for about five minutes $\left(\frac{3{,}800}{12{\cdot}4 \times 60}\right)$, and under the supposed conditions, the demand upon the station (at car axles) would be represented by a continuous reproduction of this diagram, since at the end of every five minutes (about) all cars are in the same relative positions as at the start.

We see then that on this tram line, with a very good service, having only about five minutes headway, the effect of grades alone is to cause a variation in demand for power, as measured at the car axles, varying every five minutes within limits proportional to 145 and 375.

It is pretty certain that this does not represent either the best or the worst case possible. We should get quite a different composite diagram by fixing a different set of

starting points for either set of cars; that is to say, by regarding figs. 8 to 11 as fixed and taking the two ends of fig. 4 to be joined together, forming an endless diagram capable of being cut into any four equal lengths to give figs. 12 to 15.

We might indeed by trial find such a combination of the eight diagrams as would give the best load line, and then arrange the times of starting of tramcars from each end so as to realise it as nearly as possible. This would amount to giving the cars less time at one end than at the other.

Taking fig. 16 as it stands, however, we may from it investigate the effect on central station economy of grade alone, the cars being run as described.

Assume now that the power demands at the car axles are in all cases represented proportionally at the dynamo terminals of the central station (this is not true, but is on the safe side; it underrates the variation in demand at central station; the question of the variation in gearing, motor, resistance and line losses, is only capable of investigation in a given case not generally). Assume that the con-

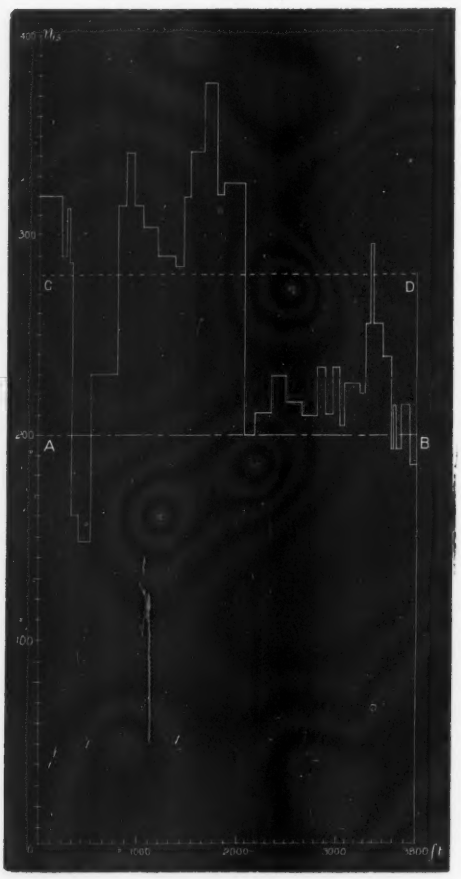


Fig. 16.

sumption of steam in an engine with varying load is approximately the same as the consumption of steam by the same engine at mean load (which Captain Sankey says is the fact, and which is accepted by Dr. Hopkinson, see Dr. Hopkinson's paper on "Electric Railways," Min. Proc. Inst. C.E., February 14th, 1893), and assume that the full load efficiency of engine and dynamo is 75 per cent.

Then the central station efficiency is that of an engine capable of doing work proportional to the number 375, and worked at a mean load proportional to the number 280 (= 8 × 35 which we already know to be mean drawbar pull with no stops). This is about 70 per cent. on the above assumptions.

The further loss of efficiency due to provision of extra power for starts would, on the same lines, be determined by adding at the highest peak the drawbar pulls due to the acceleration of such proportion of the total number of cars running as may be found in practice to be reasonably likely to start at once at that point.

If we take two out of eight the maximum power becomes

proportional to 375 + 105 = 480. While the mean power is we know proportional to 8 × (25 + 10 + 3·4) = 307. Then, on the same suppositions as in the former case, the efficiency becomes 65 per cent., further reduced to 60 per cent. if provision for the stoppage of three cars be made.

So much for the principle of the application of the theoretical traction diagram to the investigation of the direct effect of grades and starts upon central station economy.

There is also, in the case of short isolated lines an indirect effect which must not be lost sight of; this is due to the fact that provision for the wide range of power, and its sudden variations, necessitates the use of simple engines instead of compound.

Mr. Parshall (*Journal* Inst. Electrical Engineers, Vol. xxiii., p. 700) says:—"A fair value for the amount of energy taken by ordinary cars of from 8,000 to 10,000 lbs. making schedule time 8 to 12 miles per hour, is one Board of Trade unit per car mile, corresponding to 60 to 80 lbs. of steam by high-pressure non-condensing engines and belt-driven dynamos as used in small stations, or 35 to 40 lbs. by slow-speed Corliss non-condensing engines in larger stations."

This statement combines the direct and indirect losses, giving us an approximate value of the latter as about 20 to 30 per cent.

This whole question of central station efficiency, as affected by varying load on the engines, is essentially a matter for the steam engine experts, and is, I venture to say, well worthy of their careful consideration.

As Messrs. Crosby & Bell put it in the "Electric Railway," "the chief losses, as we have already seen, are in the station and in the car machinery. The former may be obviated by careful designing of the station equipment."

My object has been to indicate that the theoretical traction diagram is a very important factor in this careful designing.

(*To be continued.*)

LONG-DISTANCE TRANSMISSION.

The annexed table may be of interest as showing some of the principal electrically transmitted water powers of America, and a few of their salient features. It is compiled from particulars gathered together some time ago in a lengthy article by Mr. J. McGhie for *Cassier's Magazine*, showing the large growth which long-distance transmission has already attained in America, and indicating what may possibly be effected in the near future in Africa, where water-power is said to be a considerable item in parts of the Continent. Not much had been done before 1891, simply because of the limits possible in direct currents and the imperfections of alternators; but to-day there is almost a danger that the proprietors of water-powers will stop any further enterprise by their greediness, or that speculation will ruin a promising future. The Ouray installation was brought to a practical issue because of the high cost of coal, 72s. per ton, which enabled the transmitted water-power to save £8,000 per annum to cover interest and maintenance charges on the electrical plant. Alternating current was not then commercially practicable. The current is, therefore, direct, and is carried to 12,700 feet above sea level, through dense timber, and over a plateau where snow is often 20 feet deep, and lightning is frequent and persistent, but in spite of all difficulties, the scheme has been quite a success; so much so, as to enable low grade mines to be operated that before did not pay. At Telluride, again, very similar conditions as to climate and fuel were faced. It was, however, only after the Frankfort-Lauffen scheme in 1891 had shown what high voltage alternating current could do, that this was recognised as the only economical means of long-distance transmission. This German experiment gave a fillip to the American industry, and was followed by the San Antonio scheme, though still the single-phase current was

Locality.	Distance transmitted.	Height of fall.	Length of canal (C) or tunnel (T).	Length of pipe line.	Type of wheel.	Power.	Generators	Voltage.		Transformed down.		Date.	Current used for
								Generated.	Transmitted.	1st.	2nd.		
Guatemala	Miles. 3¾	Feet. 485	..	Feet. 4,000	Pelton ..	H.P. 500, 720	Two 1,500 light alternators.	..	..	..	..	1887	Driving arc lighting machines 7½ miles from city.
Ouray, Cal.	3¾	40	..	..	Pelton ..	..	One multipolar 200 k.w. direct-current.	800	800	..	..	..	Mining machinery.
Portland, Ore.	12	..	..	..	.. .. ..	..	Alternating	4,000	4,000	1,100	100 and 50	..	Lighting only.
Telluride, Cal.	3	320	..	..	Pelton ..	100 3,200 projected.	One alternating. Four 800-H.P. two-phase projected.	..	3,000+	..	..	..	Drives a 3,000-volt 100-H.P. alternating motor.
Bodie, Cal.	12½	..	..	..	.. .. ..	..	120 k.w. alternator, single phase.	3,400	..	..	..	..	Driving 12 H.P. synchronous motor.
Lauffen, Germany.	101+	..	..	..	.. .. ..	300	.. ..	..	25,000	..	..	1891	Driving exhibition motors.
San Antonio, Cal.	13¾, 28¾	390	1,320 (C)	2,000	.. .. ..	1,900	Two 120 k.w., single-phase.	1,000	10,000	1,000	..	..	
Hartford, Conn.	11	20	..	..	.. .. ..	..	One 300 k.w. triphase	Low.	7,000	..	..	1893	Drives 300 k.w. triphase motor for driving power and light dynamos.
Redlands, Cal.	7½, 4½	353	160 (T)	7,250	Two 2-nozzle Pelton.	..	250 k.w. triphase ..	2,500	2,500	..	..	1893	ighting, and 150 k.w. triphase ice machine motor.
Taftville, Conn.	4½	..	..	..	.. .. ..	..	Two 250 k.w. triphase.	..	..	..	..	..	Two 250 k.w. motors driving cotton mill and tramway.
Concord, N.H.	4½	..	..	..	.. .. ..	..	Two 250 k.w. triphase.	..	2,500	110	..	..	
Portland, Ore. (new station).	12	40	..	..	Victor turbines.	projected, 12,800	Three 450 k.w. triphase in place. 20 projected.	6,000	6,000	400	..	..	Drives rotary converters of 400 k.w., producing 550-volt direct current.
Folsom, Cal.	21½	55	9,500 (C)	..	Four McCormick turbines, 30".	5,040	Four 750 k.w. triphase.	800	11,000	125 250 500 1,000 2,000	..	..	Power and lighting.
Silverton ..	3	..	9,750 Flume	4' × 3'	Two Pelton double-nozzle.	..	Two 150 k.w. triphase.	2,500	2,500	..	..	..	Mining machinery.
Park City, Utah.	5½	120	3 miles (T)	..	.. .. ..	..	General Electric monocyclic.	2,500	2,500	..	..	..	
Anderson, S.C.	6	1	..	..	24-inch McCormick turbine.	..	150 k.w. two-phase ..	5,500	5,500	1,040	..	..	
Fresno, (projected).	35	1,410	6 miles (C)	4,000'	Three Pelton single nozzle.	7,000	Three 340 k.w. triphase.	..	11,000	..	..	..	General purposes.

employed, and this was delivered in Pomona and San Bernardino at a voltage of 9,500 and 9,000 respectively, the loss over 28 miles being only 10 per cent. It is said that the two lines were once connected in series to a length of 85 miles and 100 H.P. successfully transmitted, but particulars are wanting as to the efficiency. Multiphase generators were afterwards employed, the General Electric Company developing the three-phase system as well as improving the single-phase system, so as to be readily used for both motor and light purposes.

The Westinghouse and the Stanley Companies developed the two-phase system, Hartford possessed the first triphase installation, Redlands followed with a water-power scheme of some magnitude, the waste water being used for irrigation purposes. Light and power is run off the same circuit in Redlands without affecting the lighting service at Taftville, two 350 H.P. steam engines were discarded when the electric current was available.

The new works at Portland, Oregon, employ three-phase generators, directly driven by Victor turbines on a vertical spindle, similar to the Niagara machines. The frequency here is 33 cycles, because of the large amount of direct current needed for railway service, for which rotary converters are employed. The voltage of 6,000 is the highest delivered from any generator in America. Telephone, arc light, straight alternating, and three-phase wires are all strung on the same poles, without any inconvenience. Light in Portland City is distributed from the secondaries by a four-wire system, with 133 volts difference between any two wires. This and the Lowell system are the first plants converting triphase into direct currents for railway purposes. At Lowell the 360-volt generated current is raised in air blast transformers to 5,500, and carried on the same poles which carry the direct current railway feeders a distance of six miles. There the current is partially transformed down to 360 volts for rotary converters, which deliver it as 500-volt direct railway current, while the balance is carried to Nashua, a distance of nine miles further, and there converted to work the interurban Lowell-Nashua tramway, and the town lines also.

The Park City scheme utilises the water from the costly mines drainage tunnel, at a head of 120 feet, to perform the work of the mines themselves, as well as to light Park City.

Salt Lake City is to have current brought 14 miles to lighten we suppose, not merely the Gentiles. A head of water of 380 feet is available in Cottonwood Canon, and the transmission is to be at 10,000 volts. The steam plant of the electric light company will be discarded, and a powerful incentive given to the mining industry of which the city is a centre. The Fresno scheme is yet only in project; but it is the most ambitious yet planned, with its 35 miles of transmission, the longest yet attempted on strictly commercial lines. There are many smaller schemes in project, but no attempt has yet been made to develop the great masses of low grade fuel lying unused at various points as suggested by Thwaite in England, but the culm piles of Pennsylvania promise large returns to anyone who will undertake their utilisation.

The enormous power now going practically to waste at our many ironworks has been looked on as a likely economy in the near future, and we believe the success of this scheme is by no means distant. We have not in England many water-powers to use up, and if we do attempt to meddle with them there is raised up so heavy a cry of *vandal!* that the boldest may well hesitate. But it should be patent to anyone that the cost of using a water-power is very great. These American water-powers are exploited in a very thorough manner, and substantial work is done on the canals and buildings, pipe lines, and machinery, so that a water-power even when free may often only be a success because of the very heavy fuel charges, as at the Ouray mines in the annexed table, where coal had to be carried by Burros (donkeys) up one of the stiffest zig-zag tracks in Colorado. Where there is waste gas to be had, or waste fuel from which gas can be made, the expense of putting down plant to generate power, is small compared with the costly works necessary to put a water-power into shape for use. Long or even moderate distance transmission is therefore by no means to be regarded by English engineers as a line of work beyond their own immediate sphere, for it is by no means unlikely that fuel in England will provide the power that has been supplied by water so far in America, and utilised there to such good purpose.

TRANSMISSION OF POWER IN MINES.

By RANKIN KENNEDY.

I.

This subject has often been treated in papers before the various societies from different points of view, mostly with the object of publishing the superiority of electricity over everything else; however commendable this may be, it is perhaps more instructive to compare the other agents, steam and compressed air, as applied to the same purposes.

And in comparing them together for the various operations required in mining, winding, pumping, hauling, coal cutting and drilling, it will be seen in what cases electricity is superior, and why it is so. Nothing promotes the introduction of improvements more than clear proofs that the improvements actually exist, and to show how they are to be obtained. Descriptions of what has been done here and there are encouraging; but as a rule not convincing, for many things are carried out which are not improvements. It is also necessary to carefully keep an eye on rival agencies; hence it is necessary to investigate the possibilities of compressed air at its best.

Steam, if not applied direct, is, in mining work in this country, the source of the energy of the other agents.

Steam differs from the other agents, as it is the direct product of the natural elements, water, air and fuel; the energy, or at least a small part of the energy given off by the combustion of the fuel, is stored up in the water in a boiler; this energy converts the water into steam, and the energy is indicated by a pressure; this energy is converted into power by the steam engine.

Compressed air cannot be directly obtained from the combination of elements; it must be compressed by some power generated and applied to the compressor. Compressed air acts only as a carrier of the power from the steam engine, waterfall, or windmill, to the place where the work is to be done.

Electricity can be generated directly by the combination of natural elements on a small scale in the apparatus known as a primary battery, but at present this method is so expensive and troublesome, that its use is confined solely to very light work, such as ringing bells and working telegraphs. Wherever any considerable power is required, we must get our electrical energy, as we get compressed air, from a machine driven by a prime mover, such as steam. Steam being the prime mover in all three systems, it is not possible, in making comparisons, to set steam aside. We can compare compressed air and electricity as transmitters and distributors of power, for both are alike in being merely carriers of energy, exactly as ropes or belts might be compared for the purpose of transmission of power; but in all cases in mining work, steam power is the origin of the compressed air and electricity.

To begin with, we may compare the three systems from two points: first, the efficiency of the transmission, and secondly, the efficiency of the conversion into work. We may then compare them for the purpose of ascertaining their relative convenience and adaptability. This latter point of view may be the most important in underground working, although efficiency is now more generally recognised as essential in colliery working than it used to be; some people argue that as coal is very cheap at the pit, efficiency in power appliances is of little consequence, but that is now regarded by most colliery owners as a dangerous conclusion, and efficiency is insisted upon in most cases.

Power is required underground for three or four purposes, haulage, coal cutting, pumping, and drilling rock.

In many cases steam is led below to the haulage engine placed near the bottom of the pit shaft, and steam pumps are similarly worked when placed in or near the bottom of the shaft. Here the chief difficulty arises from the great length of steam pipe, and consequent condensation of steam. These are probably the only two cases underground in which steam may be seriously considered as a competitor with the two other agents.

Dip pumping, coal cutting and rock drilling can hardly ever be successfully carried on in the underground works of a pit by steam directly applied.

It might be worth while comparing all three agents for the purpose of working every machine in and about the mine.

At present we find all pits fitted out with a steam engine for winding. Then, as workings extend, steam, compressed air, or electric haulage is adopted; pumping is then, in many cases, found necessary. On the surface the engineering shop requires to be driven, also coal screening and washing machinery. All these are usually driven by steam, and by very ordinary engines of very low efficiency, taking, according to Mr. Foster Brown, not less than 8 lbs. of coal per horse-power-hour. This 8 lbs. represents not only steam used in actual work, but also steam wasted by condensation, leakage, and fall in pressure in the pipes on the surface; but if we take long pipes underground to pumps or haulage, this figure is too small, 10 lbs. per horse-power-hour being nearer the truth.

Steam may be tolerable for the surface powers, but it has, besides the low efficiency for underground work, other drawbacks; the heat radiated by the pipes and engines is objectionable, and in dry pits increases the tendency to raise coal dust.

We will consider the working of the winding engines by electricity, for here we have a case of constantly stopping and starting, and the electromotor is not a machine which works economically under these conditions. The electromotor is essentially a constant speed machine, if we require high efficiency; this fact escapes the notice of many enthusiastic writers on the advantages of electromotors.

To make the matter clear, a hydraulic analogy may be permitted. If we take a turbine water-wheel, which in fact much resembles an electromotor, it does not use up the water, but takes up its energy, neither does an electromotor use up the electricity, it only takes up its energy; the same amount of electricity comes out of the motor that goes into it, but it has given up its energy. Suppose we used a turbine for winding; every time we turned on the water to start up, a lot of water would run through before moving the wheel, and a lot more would run through while getting up speed; and as a winding engine may make 20 to 30 starts in an hour, it is evident there would be great loss.

And so it is with an electromotor. Every time it starts a lot of energy is lost, in fact, if we jam up a turbine so that it cannot move, the water may run through full bore and do no work whatever; similarly, if we fix an electromotor, so that it cannot move, a great current will flow, without doing any work.

Now, a compressed air or steam engine wastes no fluid at starting, for unless the piston moves no fluid escapes, and if it is fixed fast nothing is wasted.

For these reasons, a fluid pressure engine is superior to the electromotor, where numerous starts and stops are made with short runs between. This is the case in colliery winding engines.

It may take 20 seconds to start up a large motor under load, even with excessive current. During that time the work done is only a fraction of the power applied. Generally the loss during the time from no speed to full speed is more than 50 per cent., often 70.

This is a small matter in motors running for hours at a stretch, but in a motor running only a couple of minutes or so, and starting 20 to 30 times an hour, it amounts to a great deal.

It is evident that for winding in collieries steam has some advantages, and as the boilers can be near the engine, compressed air has no advantages.

For all other purposes electricity or compressed air can with advantage be used in colliery working, and it is to the comparative advantages and disadvantages of these two carriers of power attention is required.

Proceeding to the consideration of our special subject, it will be necessary to point out that we must divide the treatment: first, the transmission of power in mines free from gas, and secondly, in mines considered dangerous from the presence of explosive gases.

In the first case we are at liberty to select a system quite different from, and altogether inadmissible in, the latter case.

Safety is the first consideration in mining work, hence the application of electricity to machinery in fiery mines has been very cautiously approached.

There are two sources of danger: that of sparking at the brushes on the motors, and rupture, or contacts made in the cables and switches, fuses, and other parts of the distributing system.

Sparking at the brushes occurs when the load is suddenly varied, as it is in haulage and coal cutting machinery, and this sparking is very dangerous and violent, if by any means the motor is forcibly stopped or slowed down, as it often is in coal cutting machinery, so that motors with brushes are not, without extraordinary precautions, to be used in coal cutting machinery in fiery mines. The polyphase motor fortunately promises to get over this difficulty, inasmuch as it has no commutator and no brushes.

The danger of sparking brushes is often minimised, and it is claimed that no accidents have arisen from that cause; but this is a mistaken policy. It is better to recognise the danger and provide against it than to encourage a sense of false security. The fact that no accidents have occurred from sparking is due no doubt to the extreme caution displayed by colliery owners of fiery mines, to such an extent that no commutator motors are to be found in dangerous places. Haulage plants are mostly situated where explosive gases cannot readily accumulate, and so are pumping plants, and pumping motors are not prone to sparking, for the load is, as a rule, constant. It is in coal cutting where the real danger is, and for that reason alone it is a foregone conclusion that motors with commutators and brushes will never succeed in fiery mines for that purpose.

The wiring in a fiery mine costs more than double that of of a non-fiery mine, for the wires, to be safe, require to be buried, and all switches carefully closed in gas tight iron cases.

Compressed air can be used equally well in either class of mine; in fact it is a positive advantage in mines in assisting ventilation, although too much stress is not to be laid on that argument, for efficient ventilation has to be provided for in any case. It is, however, one of the advantages of compressed air that it can be used with safety anywhere.

Polyphase motors, although not so free from danger of fire, run compressed air very close on the score of safety.

Compressed air systems have not stood still in the way of improvements; recently many and great improvements have been made in the compressors, the pipe lines and motors, so much so, that for efficiency, it now runs electricity very close for long distance transmission.

Unfortunately in fiery mines, again, we cannot make use of the chief improvement in working compressed air engines, namely, the reheating apparatus; but this difficulty may be overcome to some extent, as will be referred to later on.

It may be as well now to refer to compressed air systems of power distribution for mines.

In all cases a first-class compound, or triple expansion steam engine is assumed as the source of the power.

The compressors are generally built with the engines all in a piece; in the old compressors the air was compressed in one cylinder, and without any attempt at cooling, consequently a very low pressure was generally used, and a very low efficiency obtained.

The most economical compressor is one in which heat is abstracted during compression, so that isothermal compression is obtained.

Some old compressors had water jackets for this purpose, on the air pump. Water pistons have also been used, but both these methods are inefficient. A better plan is to inject water as a fine spray into the cylinder during compression.

The best method for obtaining isothermal compression is to use a compound compressor to carry out the work in stages, cooling the air to atmospheric temperature in intercoolers between each stage of the compression.

The intercoolers are sometimes made like surface condensers, with their brass tubes circulating water for cooling.

For mining purposes low pressures are desirable, especially in coal cutting machinery, where flexible pipes are used; but even if the pressure is only 50 to 60 lbs., compound compressors are an advantage.

Another point of importance is the clearance in the cylinders and valves of the air pumps. If this is too great it unduly diminishes the output of air, and renders the pumps too small for their work. Compound compressors suffer less from this cause, as the difference of pressures at the beginning and end of the stroke is less in the cylinders than in a pump doing all the compression in one cylinder.

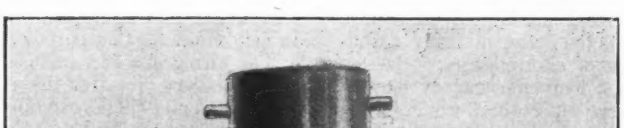
C

NEW LAMPS FOR OLD.

Our illustration shows a form of incandescent lamp, now being introduced by the Improved Electric Glow Lamp Company, Limited, which is said to possess several advantages, and to be a distinct step in advance towards perfecting and popularising electric lighting by means of the incandescent lamp, and thus keeping pace with the recent improvements in gas lighting.

The special feature of this lamp is the silver-plating, gilding, or otherwise treating the top end of the glass bulb, which is suitably shaped to form either a convex, concave, or other reflector as may be desired, whilst the lower end, or clear part of the bulb, is so designed as to allow the light to pass through it at right angles to the surface of the glass with the least resistance and the least refraction.

Silvering *per se* is, of course, an ancient process; if we mistake not, Woodhouse & Rawson supplied them years ago, and they can be obtained at the present day from a number of firms, including the Edison & Swan United Electric Light Company, Limited. The Frédureau light diffusing globes are intended to effect a like result, and Professor S. P. Thompson says that in photometric measurements he has in every case found the globes to be effective in concentrating the light in the desired direction. A table accompanying his report purports to show that a lamp nominally of 16 candle-power was giving only 8 candles in the downward direction until provided with the diffusing globe and reflector, but when so provided it gave a light downwards of 34 candles, being an increase of more than four-fold in the desired direction. The increase was of course obtained by utilising rays that would otherwise have been wasted by being emitted upwards, or in directions where they would produce little result.



Curiously enough, an American Exchange this week gives an illustration of a new desk lamp "designed to throw an intense light upon the work," and which bears a remarkable family likeness to the block which adorns this page. Whether the "Improved" bulb is so mathematically and geometrically worked out as to substantiate the advantages claimed we have had no accurate means of judging, but probably the statement is at least approximately correct.

Another interesting feature is the construction and placing of the carbon filament, so that it is co-axial with and equidistant from the reflecting surface, and as nearly as possible in the optical focus of the mirror.

It is claimed that these improvements enable the lamps to give the maximum of light upon the surface to be illuminated with the minimum of current.

The silver plating on the glass is electrically coated on the outside with copper, and afterwards varnished. The silver plating is thus protected from the direct action of external heat and air, and is said to keep perfectly bright after some thousand hours of lighting.

The lamp makes a combined lamp and reflector, which can be fitted with any lamp socket in place of an ordinary incandescent lamp, without the necessity of using an additional reflector over the top of the lamp, such as an opal shade. The advantages of such a combined lamp and reflector are obvious for many purposes, such as for engravers, watchmakers, printers, &c., and for weaving mills over the looms (although, as will be seen from one of the following reports, they are here somewhat restricted); for shop windows, theatre lighting, ships' cabins, railway signals, miners' lamps, and for interior lighting of private houses, hotels, clubs, and, indeed, for many of the purposes where ordinary incandescent lamps are now used.

The light from these lamps can be intensified several times in any given direction by the concentration of the direct and reflected light upon a limited area, and one of the special features is the use of this lamp for throwing the light on the ceiling, and thus lighting rooms, &c., with a very soft and diffused light, very pleasant to the user.

The following reports on these lamps have been made by Mr. George Annesley Grindle, M.I.E.E., whose name is known to our readers in connection with the construction of the City and South London Railway, and later with the Chloride Electrical Storage Syndicate; by Mr. H. F. Joel, jun., and by Messrs. Thomas Rhodes & Son, Limited, of the Hadfield Mills, Hadfield. We give them in sequence:—

Report on Incandescent Lamps at Hadfield Mills, Hadfield.

On Friday evening, May 1st, 1896, I visited the Hadfield Spinning and Weaving Mills, Hadfield, for the purpose of inspecting and comparing the lighting in a weaving shed, a portion of which was lighted with Edison-Swan lamps, and a portion with the improved electric glow lamps.

New lamps, both in the case of the Edison-Swan section, and in the improved electric section, had been put in. The Edison-Swan lamps were provided with opal shades, and the improved electric lamps left bare.

The whole of the lamps had been in use for three months at an average of about five hours a day. Three of the Edison-Swan lamps had failed, and were replaced for the purpose of the test. None of the improved electric lamps had to be removed, they being in perfect condition.

Plant.—The current was supplied by an Edison-Hopkinson compound-wound dynamo, with a capacity of 400 amperes at 100 volts.

Lighted Shed.—The shed was of the usual type of weaving shed, the looms back to back with a lamp suspended between every two looms.

Area under Comparison and Number of Lamps.—The area under comparison comprised the greater part of the whole shed, and was lit by 15 rows of incandescent lamps, each row having 13 lamps.

Of the 15 rows—eight rows were fitted with improved electric glow lamps, said to be 10 candle-power each, and seven rows with standard Edison-Swan lamps of 16 candle-power each—both lamps returned as 100-volt lamps. Out of the latter seven rows, however, one entire row was not alight owing to a defect in the fuse, and two odd lamps also failed to light, leaving 104 improved electric glow lamps as against 76 Edison-Swan lamps.

Energy Absorbed.—With a potential difference of 95 volts, with the same voltmeter across either circuit, the current taken by the 104 lamp circuit was 37·5 amperes—or (assuming the voltmeter to be correct) 4,845 watts in the first case, and 3,562·5 watts in the second case.

Watts per Loom.—As each lamp lit two looms, $\frac{4,845}{152}$; or 31·87 watts per loom were absorbed in the Edison-Swan lamp portion of the shed, and $\frac{3,562}{208}$, or 17·13 watts per loom in the improved electric glow lamp portion.

Saving in Energy.—Or a saving in energy of 46·2 per cent.

Light.—The light on the looms and work, owing to its concentration and reflection, was easily discernible to be better in the case of the improved electric glow lamps, although the actual candle-power per lamp was less.

From general observation, checked by a rough photometric test of the shadows thrown by two lamps, I am of opinion that the illumination on the cloth in process of weaving was at least 25 per cent. better in the case of the improved electric glow lamps.

From this inspection, I am of opinion that the new lamp is a great improvement on the Edison-Swan type, and for all purposes when

direct illumination is required, must come into extensive use, and result in a large saving to consumers.

31, Wilson Street,
Finsbury Square,
London, E C.

Report on Trial of "Improved Glow Lamps" in Comparison with "Ediswan Lamps" Lighting Areas of Same Mill. February 19th, 1896.

On January 13th, 1896, I went with Mr. Fanta to Messrs. Rhodes and Company, Limited, Cotton Mills, Stadfield, near Manchester, and to Mr. Fanta's instructions changed 104, 105 volt 16 C.P. "Ediswan Lamps" for 104, 100 volt 10 C.P. "Improved Glow Lamps." These lamps were in eight rows of 13 each.

A new and freshly calibrated ampere meter and a resistance were fixed in the circuit with the lamp switch, and a new and freshly calibrated volt meter across one of the lamps.

The resistance was inserted in the circuit to reduce the 5 volts difference between the lamps and the mill mains. An ampere meter also new and freshly calibrated, and checked with the other ampere meter, was fixed in the other circuit with a lamp switch which controlled 91 100 volt 16 C.P. new "Ediswan lamps," in 7 rows of 13 each.

The following were the results:—

104 improved glow lamps required

100 v. × 36 a. = 3,600 watts.

91 Ediswan lamps required.

100 v. × 58 a. = 5,800 watts.

In order to compensate for the extra row and larger area lighted by the "Improved Glow Lamps" it is necessary to deduct ⅛ (equal to one row of lamps) from the "Improved Glow Lamp" circuit, that is 3,600 − 450 = 3,150 watts, against 5,800 watts used by Edison-Swan, showing a saving of 46·7 per cent. over Edison-Swan lamps for lighting the same area, under the same conditions and upon equal terms.

Both the manager, chief engineer, and the work-people said the light given by the "Improved Glow Lamps" was quite equal to the larger C.P. Ediswan lamps.

The Ediswan lamps had opal shades, and the improved glow lamps had no shades.

Report on Patent Lamps.

The new lamps supplied from London have been in work for three weeks, and our report is as follows:—

104 lamps have been in use in the weaving sheds, twisting and sizing departments. They gave good results in the twisting and sizing rooms, but are not so satisfactory in the weaving, the rays of light being too concentrated on the spot, and not spreading enough for the weaver to see the back of the beams.

We are afraid this fault of not spreading the light will be detrimental to their success in the spinning and card room.

The 104 lamps in use, 10 C.P., worked at 35 amperes, against 55 amperes for 91 new Edison-Swan 16 C.P., thus showing saving in power of over 20 amperes in favour of the new lamp.

February 19th, 1896.

Following these reports, we have been favoured with a most ingeniously figured out comparison with ordinary lamps, intended to show the economy of the "Improved electric lamps," which reads as follows:—

"From Mr. Grindle's report, it is clear that an Improved electric lamp of 10 candle-power (list price 2s. 9d.), whilst giving a light 25 per cent. better than an Edison-Swan lamp of 16 candle-power (list price 1s. 6d.) consumes 46 per cent. less current."

"An Edison-Swan ordinary lamp of 16 candle-power has an average life of 1,000 hours, and consumes, as above, 63·75 watts per hour, which is equivalent to 63·75 Board of Trade units, during its life."

"The average charge for current made by supply companies and corporations is, say, 6d. per Board of Trade unit; the cost for current, therefore, for 1,000 hours, will be £1 11s. 10½d. Add to this the first cost of the lamps, and the total cost for 1,000 hours' lighting will be £1 11s. 10½d. + 1s. 6d. = £1 13s. 4½d."

"Now, an Improved electric lamp of 10 candle-power, whilst giving 25 per cent. more light during a life of 1,000 hours, only consumes 34·25 Board of Trade units (see Mr. Grindle's report)."

"Again, taking the cost of current at 6d. per Board of Trade unit, the cost for 1,000 hours' lighting will be, in round figures, 17s. 1½d. + 2s. 9d. (the first cost of the lamp) = 19s. 10½d."

"For every 10 candle-power Improved electric lamp fitted in lieu of a 16 candle-power Edison-Swan ordinary lamp (assuming the life in each case to be 1,000 hours), the actual net saving effected, after taking into consideration the increased cost of the lamp in the first instance, is, therefore, 13s. 6d."

"The total number of hours per annum that a lamp is burning is approximately 1,000, assuming the hours of lighting to be from dusk till 9 p.m."

"Every 10 candle-power Improved electric lamp saves its purchaser 13s. 6d. per annum."

"In theatres, cafés, hotels, public houses, ships, &c., where the lamps are used a longer time, the saving will be greater in proportion."

We have every desire to be scrupulously fair both to the old lamps and the new, and therefore we feel compelled to make a few comments on the foregoing comparison.

First of all it can scarcely fail to be noticed that so far as actual candle-power rating is concerned the Ediswan lamps have the advantage, as Mr. Grindle candidly admits, thus: 104 × 10 = 1,040 C.P. for the new lamps, as against 76 × 16 = 1,216 C.P. for Ediswan.

Dividing the watts in each case by the total candle-powers, we get 3·4 watts per candle in the new, and 4·0 watts in the old. So far, therefore, as the actual candle-power given out by the filament is concerned, it is difficult to see where a saving of 46 per cent. comes in.

Now as to the real value of the lights given in the two cases.

To give this comparison any definite meaning, the Ediswan lamps measured should have been of the silvered reflecting type, for the veriest tyro knows perfectly well that in one case the light is all reflected, and so multiplied in a given direction, whereas in the other the luminosity is practically all round, the opal shade of the Ediswan lamps being no reflector in the true sense of the word.

Some two or three years ago we were shown a miner's lamp, nominally of one candle-power, which the inventor asserted gave, by means of a silvered reflector at the back, 100 candle-power with no greater consumption of electrical energy. It is manifestly clear that very erroneous impressions of the candle-power of different incandescent lamps, with filaments apparently of the same material, can be formed, unless they are measured under identically the same conditions, and there is nothing to prevent the Edison-Swan Company making precisely similar claims to those put forward on behalf of the "Improved Electric Glow Lamp" if they choose, for as a matter of fact, the company does supply lamps silvered at the top, bottom, or sides, as desired.

It is not to be understood from the above remarks that we have any objections to urge against the Improved lamp; indeed, rather the contrary. We simply desire to enter a mild protest against claims which cannot justly be sustained on the grounds that the comparisons which have been made are based upon wrong premises.

We recently visited the show-rooms of the company at 103, Queen Victoria Street, where we saw, in addition to a very large stock, a great variety of the lamps fitted for show purposes, and plated in various ways, and are pleased to add our testimony in favour of these new lamps, which we consider will be of great value, and materially assist electric light enterprise, more particularly if the guarantees as to their durability are borne out in practice.

We understand that lamps of all used voltages and candle-powers can be obtained, and lamps have been in use for some time, amongst other places, at the Midland Railway Hotels, the Adelphi Hotel, Liverpool, the Café Monico, the Cannon Street Hotel, St. Enoch's Central Hotel, Glasgow, Messrs. Spiers and Pond's, Victoria Hotel, Manchester, Criterion Restaurant, Piccadilly, W., the Junior Carlton, Prince's, United Service, Conservative, and the City Athenæum Clubs, Royal Societies, the library of the Royal Institution, the *Financial Times* Printing Works, the Empire, Gaiety, Daly's, and other theatres, the Great Northern Railway, the Board of Works, Dublin, Hadfield Mills, Hadfield, Derbyshire, the Shipley Collieries, Derby, Smith's Dock Company, Limited, North Shields, &c., and have resulted in repeat orders in most instances. The company have contracts in hand for the supply of over 2,000,000 lamps.

After all said and done, the best proof of the utility of the new lamp lies in the lapse of time, and we can only express the hope that it may help forward the true interests of electric lighting.

ON ALTERNATING CURRENT-RUSHES IN CONDENSERS.

By BERNARD P. SCATTERGOOD, M.A., Oxon.

(*Concluded from page* 135.)

28. If the theory of a high frequency current in the circuit be correct, it follows that a choking coil should, under the conditions of the experiments above described, show a higher impedance with a given voltage at its terminals, than when subjected to the same pressure at the normal frequency given by the alternator, and unmodified by the presence of a spark-gap in the circuit. In order to test this point, I arranged the thick coil of a small iron-cored transformer, of which the conversion ratio was about one to five, in parallel with a 16 candle-power lamp, L, and an electrostatic voltmeter, V, the combination being put in series with the condenser and spark-gap (see fig. 10). (To avoid confusion, in speaking of the transformers used in these experiments, I shall henceforward always call the coil which is in circuit with the condenser on the high tension mains, the *primary* coil, whether the number of turns on it be more or less than on the secondary.) The secondary circuit of the transformer was left open, so that in this case the primary was acting simply as a choking coil. With a frequency of 83 ~ and 2,000 volts on the mains, the glow of the lamp, when the gap was short-circuited, was imperceptible to the eye, and the pressure at its terminals, as indicated by the voltmeter, was something less than 5 volts. On opening the spark-gap and allowing sparks to pass, the lamp glowed at from 40 to 50 volts. When the transformer was disconnected, so that all the current passed through the lamp, the latter glowed at from 20 to 25 volts with the gap short-circuited, and at about 60 when sparks were passing (see Sec. 3). This experiment seemed to show that the impedance of the transformer was greater on a sparking than on a normal circuit; if it had remained the same, the *ratio* between the pressure at the terminals of the lamp on the sparking and non-sparking circuits ought also (neglecting the slight difference due to variation in the resistance of the lamp arising from difference of temperature) to have been the same whether the transformer were in circuit or not. As a matter of fact, instead of being the same, this ratio was considerably less on the non-sparking circuit.

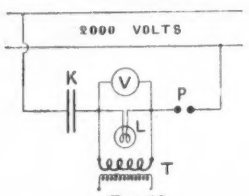


Fig. 10.

This experiment is, perhaps, not very conclusive; but I shall describe others which show very clearly an increase of impedance.

29. The lamp across the transformer terminals was removed, and connected instead in the series circuit, to serve as an ammeter (L_0, fig. 11); electrostatic voltmeters V_1 and V_2 being placed across the primary and secondary coils of the transformer. The results are given below (2,000 volts on the mains, periodicity 83 ~) :—

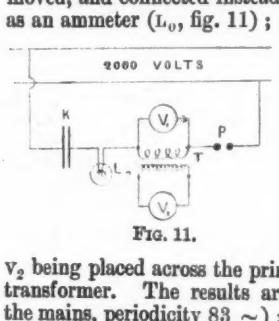


Fig. 11.

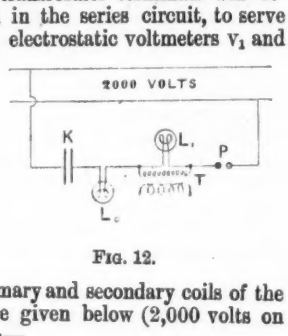


Fig. 12.

Gap short-circuited :—

L_0, 25 to 30 volts by eye (equivalent to a current of ·15 amps.).

V_1, too low to read.

V_2, 15 volts.

(V_1 and V_2 will, of course, in this case indicate pressures in the proportion of the normal conversion ratio of the transformer; that is, there will be about 3 volts at the terminals of V_1.)

Gap sparking : L_0, about 70 volts by eye.

V_1, 81 volts.

V_2, off the scale (the voltmeter was graduated up to 240 volts).

In order to bring the deflection of V_2 within the limits of the scale, I reduced the pressure on the mains to 1,600 volts. The readings were then as follows :—

L_0, 50 to 60 volts by eye.

V_1, 62 volts.

V_2, 220 volts.

At 2,000 volts, therefore, we should have (increasing the above pressures in proportion), L_0 = about 70 volts (equivalent to a current of ·35 amperes), $V_1 = 78$ volts, and $V_2 = 275$ volts.

We have thus data by which to estimate the amount of increase of impedance observed in the experiment of Sec. 28. The pressure at the terminals of the primary coil has increased from about 3 volts on the normal, or non-sparking, to 78 or 80 volts on the sparking circuit, thus showing an increase of between 20 and 30-fold, while the current in the coil has only increased from ·15 to ·35 amperes. Under ordinary conditions, of course, any increase of current in the primary would be accompanied by a *proportional* increase of terminal pressure. In the present case, the terminal voltage rises to a value about *eleven times* as great as that which would, under normal conditions, correspond with the observed increase of current. This can only be accounted for by an increase in the impedance of the coil due to a change of periodicity.

30. In the next experiment an air transformer was used, which had been originally constructed for experiments with Leyden jar discharges. The primary consisted of about 100 turns of No. 24 silk-covered wire, wound on a glass cylinder 2 inches in diameter and 7 inches long, the winding covering a length of about $4\frac{3}{4}$ inches. Each turn was insulated from its neighbour by a silk thread. The resistance of the primary was about $1\frac{1}{2}$ ohm, and its self-induction at ordinary frequencies quite negligible. The secondary winding, which surrounded the primary, was of 17 turns of No. 22 cotton-covered wire, about a quarter of an inch between each turn, wound on a glass cylinder $2\frac{1}{4}$ inches in diameter. The whole was arranged for use in an oil bath; on this occasion, however, it was used simply as an air transformer. The thin wire coil was connected in series with the condenser and spark-gap. The secondary circuit of the air transformer was left open, and in parallel with the primary was placed a 16 C.P. lamp (L_1, fig. 12). A similar lamp, L_0, placed in series with the combination, served as an ammeter.

I found that using a periodicity of about 83 ~, with the gap short-circuited, lamp L_0 showed from 25 to 30 volts, indicating about ·15 amperes passing, while nothing was visible on the lamp L_1; a result which was only to be expected, the low resistance of the coil in parallel acting as an almost complete short circuit to it. On sparks being allowed to pass, however, the lamp, L_0, in the main circuit glowed at from 80 to 85 volts, indicating ·4 amperes, while L_1 lit up to about 20 volts. As a rough estimate, we may take it that of this current ·3 amperes passed through the coil. Now, 20 volts at the terminals of a No. 24 wire of only $1\frac{1}{2}$ ohm resistance would at ordinary frequencies, assuming a negligible self-induction in the wire, send a current of nearly 14 amperes through it. This figure was verified by experiment at 83 alternations, and the self-induction of the coil was thus shown to be negligible at this periodicity, as compared with the resistance. (It may be noted in passing that with 20 volts at the terminals of the coil on the normal circuit the wire got very hot, as might have been expected; whereas on the sparking circuit, with the same terminal pressure, it kept perfectly cool.) The impedance of the coil in the two cases, sparking and not sparking, must be, for the same terminal pressure, inversely as the currents, or as 14 is to ·3; that is to say, it is about 47 times as great on the sparking as on the normal circuit. This means an increase of about seventy-fold in the value of $2\pi n L$, and as L depends only on the geometrical data of the coil (there being no iron in the core) the effective frequency of the current must have increased by this amount.

31. The impossibility of measuring the very low voltage

at the terminals of the primary coil on the non-sparking circuit made it difficult to form a reliable estimate of the increase of impedance, by a comparison of the terminal voltages. However, as a matter of curiosity, I removed the lamp, L_1 (fig. 12), and measured the pressure across the primary coil on the sparking circuit, which I found to be about 26 volts. On the non-sparking circuit the terminal pressure could hardly be more than a small fraction of a volt; the C R volts may be taken as ·15, and assuming the impedance of the coil under these conditions to be three times this quantity, the terminal pressure is thus brought up to nearly half a volt. The increase of impedance then works out at about fifty-fold, which is not very different from the previous estimate.

32. The next experiment tried was a most striking one. In this case, also, an air transformer was used, of which the primary (*a*, fig. 13) consisted of 245 turns of No. 16 wire in seven layers; length of coil, 3 inches; inside diameter, $5\frac{5}{8}$ inches; outside diameter, $6\frac{3}{4}$ inches. The secondary (*b*) was No. 14 wire, eight layers, with a total of 324 turns; length of the coil, $4\frac{1}{2}$ inches; inside diameter, $3\frac{1}{2}$ inches; outside diameter, 5 inches. The conversion ratio, estimated by the turns, is therefore about 3 to 4; but experiment showed that at 83 alternations, a current of about 20 amperes through the primary coil, *a*, caused a lamp on the terminals of the secondary to glow at about 35 volts, the pressure at

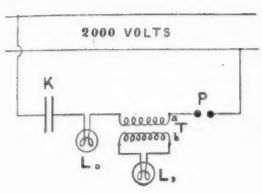


Fig. 13.

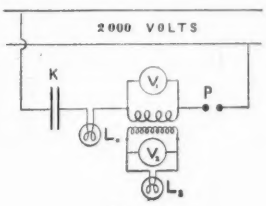


Fig. 14.

the primary terminals being rather more than 70 volts. (This difference between the calculated and actual conversion ratios is owing to the large amount of magnetic leakage.)

Coil (*a*) was then put in the condenser and spark-gap circuit, lamps being placed, one (L_0) in the main circuit as an ammeter, the other (L_2) across the terminals of *b*.

The results were as follows:—

Not sparking: Lamp L_0, about 30 volts.
" " L_2, nothing visible.
Sparking: Lamp L_0, 70 to 80 volts by eye.
" " L_2, 30 to 35 volts.

This experiment showed that a current of less than half an ampere through coil *a* was able to induce in coil *b* a pressure of 30 to 35 volts on the sparking circuit, while on the normal (non-sparking) circuit a current of 20 amperes was required to produce the same effect.

33. Next, the primary of the same transformer was put in series with 32 100-volt 16-candle-power incandescent lamps across the high tension mains, the pressure on which was about 2,200 volts at the time. The lamps glowed, of course, at about 70 volts, but nothing could be detected on the lamp across the secondary of the transformer. Here, again, comparing the last two experiments, we have two currents of apparently the same strength passing through the primary of the transformer; yet in the one case a lamp on the secondary glows at 35 volts, in the other no glow at all is visible. This difference must obviously be due to a difference of some kind in the two current-curves; and a difference in the "form-factor" alone, to use Dr. Fleming's word, is hardly sufficient to account for the effect observed, which seems to demand a difference in the effective periodicity in the two cases.

34. If we return, now, to the experiment of Sec. 29, with the iron-cored transformer, it will be noticed that the conversion ratio has altered from 1 to 5 on the normal circuit to something approaching 1 to $3\frac{1}{2}$ on the sparking circuit. This curious effect, of the change of conversion ratio of a transformer under very rapid alternations has been noticed before. Tesla, in his famous lecture at the Royal Institution in February, 1892, said:—"In operating with very rapidly alternating currents this ratio (*i.e.*, that of the number of turns in the primary and secondary coils) does not convey even an approximate idea of the ratio of the electromotive forces in the primary and secondary circuits."

35. When current is taken from the secondary this alteration in the conversion ratio is still more marked. A lamp being placed across the secondary terminals (fig. 14), the following results were obtained:—

Gap not sparking:—L_0, as before, 25 to 30 volts,
V_1, V_2 } each too low to read,

(There is, however, no reason to suppose that the ratio of V_1 to V_2 was other than 1 to 5, the normal conversion ratio).

Gap sparking: L_0, 70 volts.
V_1, 22 to 24 volts.
V_2, 10 volts.

Thus the effect of loading the secondary of the transformer, the primary being in series with a condenser and spark-gap, is actually to alter the conversion ratio from $\frac{1}{5}$ to nearly 2.

It may be said that the experiment, which was repeated several times, gave very irregular results, V_1 sometimes showing so much as 65 volts; but in all cases the pressure indicated by V_1 was much greater than that shown by V_2.

36. The alteration of the conversion-ratio of the transformer is easily accounted for on the hypothesis of high-frequency currents. It will be noticed that the alteration is in each case in the direction of a diminution of the pressure on the secondary terminals. It is in fact due to an enormous exaggeration, under high frequencies, of the magnetic leakage, which is very small in most transformers and at ordinary periodicities; but in all cases it increases very rapidly as the frequency rises, varying indeed as the square of the number of alternations per second (see Prof. Perry, *Journal Inst. Elec. Eng.*, Vol. xxii., p. 17). Thus a very high frequency has the effect of producing such a considerable leakage-drop as to alter the conversion ratio of the transformer very materially, and even to change what is under ordinary conditions a "step-up" into a "step-down" transformer when running under the abnormal conditions produced by the introduction of a spark-gap into the circuit.

37. The principles which underlie the experiments above described are, of course, as pointed out in Sec. 8, well known. But the results themselves are, I venture to think, both novel and interesting, and especially so at the present time, when Röntgen's discovery has given an additional impetus to the search in which so many were already engaged, for the ideal illuminant, which will produce a maximum of light with a minimum of heat-waste. We are waiting just now for a practical system of electric lighting by means of vacuum tubes excited by currents of high frequency and potential, and it is possible that the method I have described may ultimately be developed into a system of electric lighting, in which the transmission will be effected by an ordinary high-tension alternating system, while the lamps will be vacuum tubes, excited by the high-frequency currents produced by the aid of condensers and spark-gaps in the secondary circuits (also wound for high tension) of transformers placed across the mains.

THE HESS-RAVEROT-WEST SYSTEM OF TELEPHONE EXCHANGES.*

By J. H. WEST.

Sureness and rapidity of service take the first place among the points of view from which to judge of the value of a telephone system; both these factors point strongly to the desirability of uniting all the subscribers in a town into a single exchange; this is

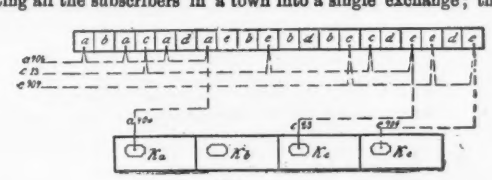


Fig. 1.

even more the case with inter-urban services, so that the time for effecting communication may be reduced to a minimum in working over the costly trunk lines, and the greatest possible amount of work got out of them. Consequently, telephone engineers have sought

* Reproduced from *Electrotechnische Zeitschrift* at the request of the author.

for some time to build their exchanges as large as possible in view of the increasing spread of telephony. In the first place, by means of the multiple system, it was sought to increase the number of possible connections by making the individual jacks smaller, so as to be able to mount more of them on one board, the size of which is naturally limited by the reach of the operator. In this way it has been possible to bring the number of subscribers' connections up to 10,000 with the use of the multiple board system.

This solution is, however, no longer sufficient, and can only be considered a temporary expedient, since it is likely to militate against a successful service. The problem has been more effectually solved by others, who have chiefly gone on the plan of increasing the number of possible connections. To this category belong the systems of Siemens & Halske, and of Engelmann, the kindred "divided board" system in use in Albany, and the "express" system of San Francisco. By means of these, which differ more or less from the ordinary multiple system, it has been possible to connect up a far greater number of subscribers to one exchange than the above-mentioned 10,000; they, however, all necessitate the making and breaking of communication at two places, in the same way as when in a town two or more exchanges are fitted on the multiple system, and therefore they do not usually offer sufficient advantages, as far as the service is concerned, to justify relinquishing the economy of wires obtained by the establishment of several exchanges; under certain conditions, however, they may do good service.

A successful and rational solution of the problem has been found by Messrs. G. A. Hess and P. E. Raverot in Paris, who have devised a new plan of connections for exchanges, based on the principle of arithmetical combinations; with this combination connection a communication need be made and interrupted at one place only, thus securing centralisation in one exchange, and improvement of the service.

A diagram of the Hess-Raverot combination connection is shown in fig. 1. In this system the subscribers are divided into sections, which may be previously designated by the letters of the alphabet; as will be shown later, each section may comprise 1,000 subscribers. Each section is represented by a number of jack-panels, with one jack for each subscriber of the section, and these jack-panels are severally connected in pairs to constitute connection-boards; for example, if there are four sections, *a*, *b*, *c*, *d*, and the connection boards are arranged in a row, we obtain the following series:—

ab ac ad bc bd cd.

As the lines of the section *a* are led in multiple through the jack-panel, *a*, and those of section *b*, through the jack-panel, *b*, and so on, the connection boards represented by the above series of letters render it possible to connect any two subscribers directly with each other. For example, if *a* No. 12 calls *b* No. 209, the connection is made by means of a double cord on the board, *ab*, and if *a* No. 12 calls *d* No. 35, on the board *ad*. From the connection boards the lines go to the call-board, where they are each provided with a jack and an indicator in such manner that the jacks and indicators of one section constitute a board divided among several operators. An operator at the call-board, when an indicator falls, can connect himself with the corresponding subscriber, *e.g.*, *a* No. 12, and can receive his instructions, *e.g.*, *b* No. 209. He then has to pass on these instructions to that connection board where alone the desired connection can be made. In the present case this will be the board *ab*. This he does by telephone "*b* 209 *on a* 12," and the operator at board *ab* then makes the requisite connection, and disconnects when the conversation is finished.

The number of sections can obviously be increased to any extent, without the mode of working being altered; and thus, whilst still preserving a rational and rapid service, exchanges for 50,000 subscribers or more may be constructed.

This mode of connection offered so many advantages, that it seemed to me useful to try it practically. Accordingly, with the assistance of Messrs. Naglo Brothers, I have worked out a system on these lines, and erected a small experimental exchange at the Berlin Exhibition, 1896, which I will now proceed to describe.

If we consider the above-mentioned series of connection boards as a continuous series of jack panels placed side by side,

abacadbcbdcd,

it will be seen that each letter stands next every other twice over; for example, at the beginning of the series we have *ab* and *ba*, and then *ac* and *ca*; the connections can, therefore, be made at two places, which is evidently superfluous, therefore several letters may be omitted from the above series, which then reduces to

abcadbcd,

in which each letter stands next every other only once. For an exchange with five sections we should have the following series:

abcadbecdea,

in which case, as compared with the series for four sections, an *e* is interpolated between the second *b* and the second *c*. Attention must be given to this in view of future extensions, and, therefore, for four sections we have, finally,

abcadb — cd,

Where the — indicates that the corresponding jack-panel is left provisionally empty, in order to accommodate later on the jacks for section *e*. For an exchange with 10 sections, the series would be

abcadbecdeafbgcfdgefgahbichdiehfighiakb — ckd — ekf — gkh — ik,

Where there is already provision made for an eleventh section, *l*, so that extensions are easy.

This series arrangement of jack panels necessitates the carrying of all the subscribers' lines along the whole series of boards, but in doing this a limit is very soon reached, when this carrying along can no longer be practically done, since the number of wires and their length become too great. When this limit is reached, the arrangement shown in the following diagram offers a convenient run for the wires.

The original arrangement of Hess and Raverot was as follows:—

ab	*ac*	*ad*	*ae*	*af*	*ag*
	bc	*bd*	*be*	*bf*	*bg*
		cd	*ce*	*cf*	*cg*
			de	*df*	*dg*
				ef	*eg*
					fg

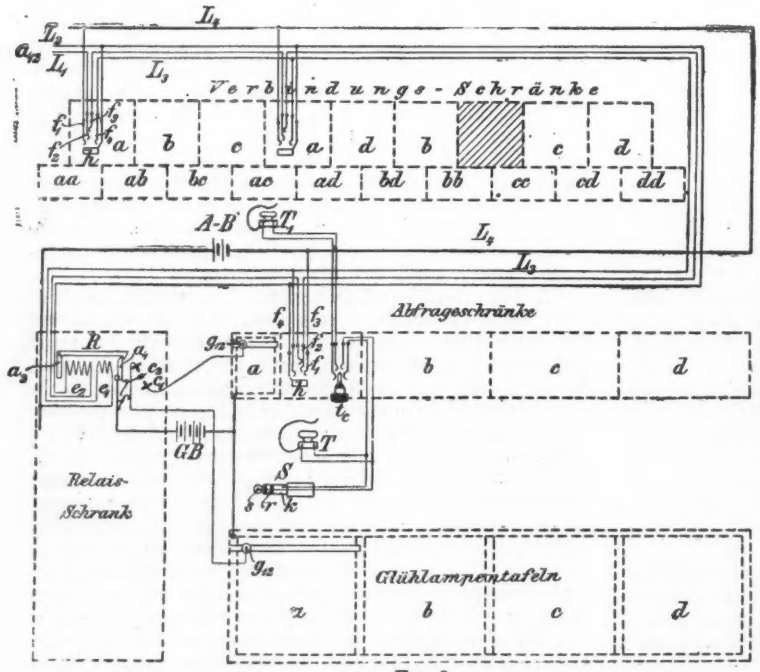


Fig. 2.

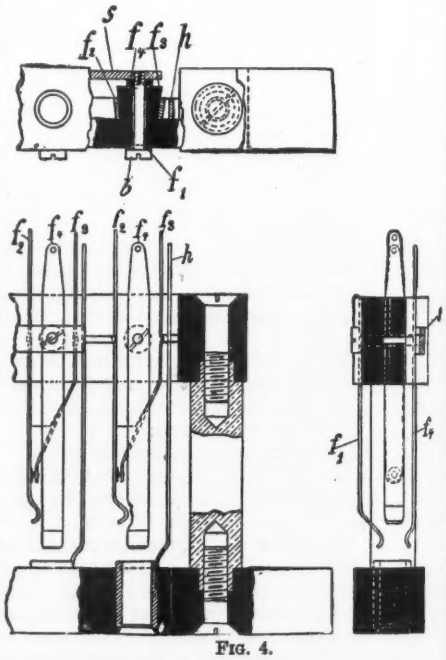


Fig. 4.

where the a wires run along the upper series of boards, and the c wires, for instance, as indicated, run through the second board of the first series, the first board of the second series, and then all the boards of the third series. This arrangement, however, entails the drawback that the operators are double in number; the drawback can, however be readily got over, if two letters, instead of one, are combined with all the others in a horizontal series, as in the following diagram:—

$$a\,b\,c\,a\,d\,b\,e\,a\,f\,b\,g\,a$$
$$c\,d\,e\,c\,f\,d\,g\,c$$
$$e\,f\,g\,e$$

For 20 sections, a to u, we obtain the following arrangement, which indicates a simple course for the wires, for instance, the i wires as shown by the two lines.

$a\,a\,b\,c\,a\,d\,b\,e\,a\,f\,b\,g\,a\,h\,b\,i$	$a\,k\,b\,l\,a\,m\,b\,n\,a\,o\,b\,\mathbf{p}\,a\,q\,b\,r\,a\,s\,b\,t\,a\,u\,b\,b$
$c\,c\,d\,e\,c\,f\,d\,g\,c\,h\,d\,i$	$c\,k\,d\,l\,e\,m\,d\,n\,c\,o\,d\,p\,c\,q\,d\,r\,c\,s\,d\,t\,c\,u\,d\,d$
$e\,e\,f\,g\,e\,h\,f\,i$	$e\,k\,f\,l\,e\,m\,f\,n\,e\,o\,f\,p\,e\,q\,f\,r\,e\,s\,f\,t\,e\,u\,f\,f$
$g\,g\,h\,i$	$g\,k\,h\,l\,g\,m\,h\,n\,g\,o\,h\,p\,g\,q\,h\,r\,g\,s\,h\,t\,g\,u\,h\,h$
$i\,i\,k\,l\,i\,m\,k\,n\,i\,o\,k\,\mathbf{p}\,i\,q\,k\,r\,i\,s\,k\,t\,i\,u\,k\,k$	
$l\,l\,m\,n\,l\,o\,m\,p\,l\,q\,m\,r\,l\,s\,m\,t\,l\,u\,m\,m$	
$n\,n\,o\,p\,n\,q\,o\,r\,n\,s\,o\,t\,n\,u\,o\,o$	
$p\,p\,q\,r\,p\,s\,q\,t\,p\,u\,q\,q$	
$r\,r\,s\,t\,r\,u\,s\,s$	
$t\,t\,u\,u$	

The general diagram of connections for an exchange with four sections is shown in fig. 2. The exchange apparatus comprises the connection boards, on which the connections between subscribers' lines are made; the call-boards, where calls are received; the relay boards, which carry the indicators arranged as relays, and a bank of glow lamps, which show whether a line is engaged or not. The double line of a subscriber belonging to section a passes first through the two jack panels, a, a, of the series of connection boards, the jacks for the lead being in series, and for the return in parallel, as shown in the diagram. From the connection boards the line goes to the call-board of the corresponding section (a), where it is connected to a similar jack; from here it goes to the indicator relay R on the indicator board, which is similar in construction to the well known self-restoring indicators of the Western Electric Company. The front armature, a_1, of this relay can take three positions: the position of rest, as shown; the drop position, when the spring, f, rests on the lower contact, c_1, and the upright position, when f rests on c_2. In the drop position, the spring, f, closes the circuit of a glow lamp, g_{12}, on the call board, in the upright position that of the glow lamp, g_{12}, in the bank of lamps, which is so situated as to be visible from all parts of the exchange, and shows whether the subscribers' lines are engaged or not. Besides the two speaking lines, L_1, L_2, of the subscriber, there is a third line, L_3, which goes from the restoring coil, e_1, of the relay indicator, and is connected to the springs, f_4, of all the jacks of the corresponding subscribers' lines. A fourth line, L_4, which is common to all the jacks in the exchange, serves to connect the restoring battery, A, B, on one side to the spring, f_1, of the jacks, and on the other side, to each of the relays.

The method of working is thus as follows:—

When the subscriber (a, No. 12) sends a calling current, the electro-magnet, e_2, attracts its armature, a_2, whereby the front armature, a_1, is released and drops forward, so that the circuit of the glow lamp, g_{12}, on the call board is closed; the lighting up of this lamp serves as a call signal to the operator, who then strikes his triple connection peg, S, which is connected to his instrument, T_1, into the jack of the similar number, h_{12}, and is thus in direct communication with the subscriber, since the body, k, is in contact with the sleeve, h, and the point, s, with the spring, f_2, which it lifts off the spring, f_3; by the separation of f_2 and f_3, the calling electro-magnet, e_2, of the relay is cut out of the talking circuit, and at the same time the local circuit of the restoring electro-magnet is closed, owing to the insulated collar, r, on the peg, S, putting the two springs, f_1 and f_4, of the jack into metallic connection; consequently, e_1 attracts its armature, a_1, breaking the circuit of the glow lamp, g_{12}, on the call board, and closing the circuit of glow lamp (g_{12}) on the bank of lamps. Thus the latter lamp is alight so long as this or any other jack of the corresponding line is pegged, and accordingly shows that the line, a, No. 12, is engaged.

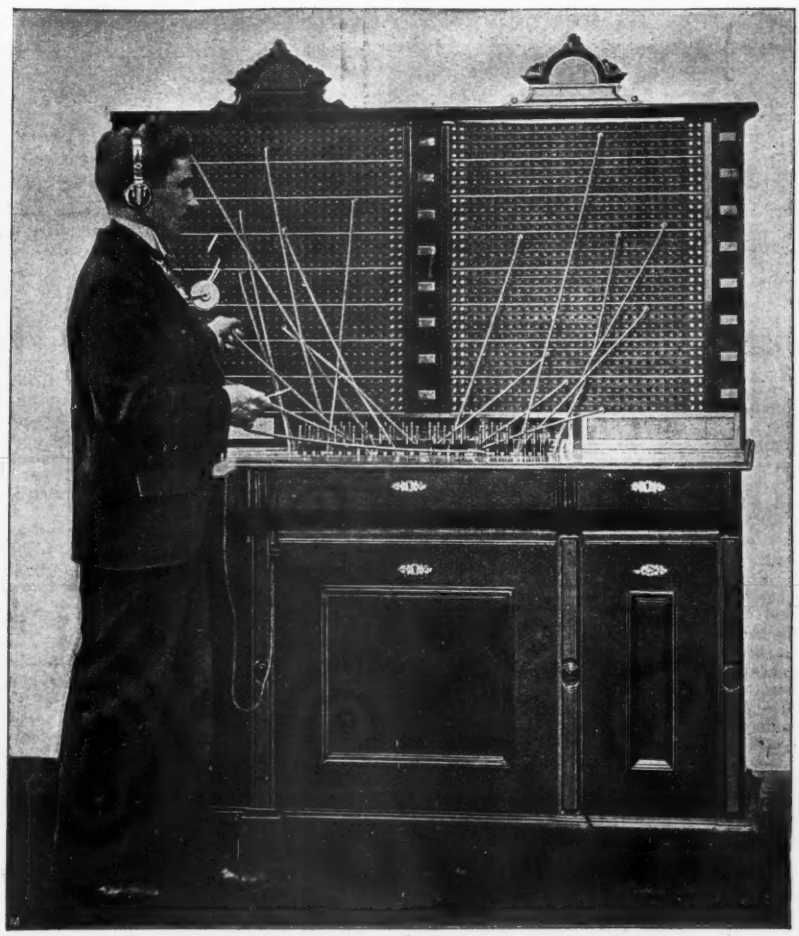


FIG. 3.

After pegging the jack, the operator says, as usual, "Here," when the subscriber gives the number he wants, *e.g.*, b No. 209. The operator looks up from his table at the bank of glow lamps, to see whether the required line is disengaged or not; the former is the case if the glow lamp No. 209, on the panel b is not alight.

If the line is engaged, the operator replies: "Line b 209 is engaged," and unpegs the jack, breaking the local circuit of the restoring electro-magnet, e_1, so that its armature, a_1, is left free; it then drops forward until it is stopped by the drop lever in the position shown, on which the glow lamp, g_{12}, on the bank goes out.

If the line wanted is disengaged, the calling operator must communicate the connection wanted to the operator, who alone is in a

position to make it; for this purpose he has on his table a number of speaking keys, by means of which he can communicate with those operators who can complete the connection of his section (a) with the other sections; these are the operators oa, ab, ac, ad, the corresponding keys are marked with the letters a, b, c, d. In the present instance, the operator depresses the key, d—shown at t_d in the figure—and at once gives the instruction: "b 209 on a 12," when the connecting operator joins up the two lines by a cord. In doing this, the corresponding relays are cut out of the talking circuit, and the corresponding glow lamps on the bank are lighted up.

On receipt of the call-off signal, the connection is interrupted as usual, and the glow lamps go out.

It is at once apparent that the sections must be made as large as possible, for the larger the sections the fewer they are, and therefore the fewer the number of jack panels necessary. The number of subscribers in a section must, however, be gauged by the fact that one connection operator must be able to make all the connections between two sections. The size of the sections will therefore depend on (1) the number of simultaneous connections at the busiest time of the day, and (2) the number of connections which one operator can manage during the average duration of a conversation. The constructive arrangements have no effect on the former number, but the latter is in great measure dependent on the construction and method of working of the system, which leads at once to the necessity of making the handling of the communication cords as simple and expeditious as possible. This is done in the present system by the use of automatic devices which effect some of the arrangements to be repeated at every connection without the special aid of the operator, and at the right moment, so that the actual work of the operator is limited to pegging and unpegging the jacks. With such an easy task one operator can easily manipulate 30 pairs of pegs.

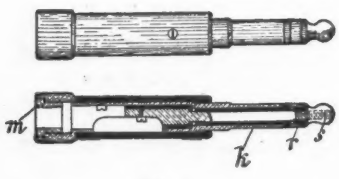


Fig. 5.

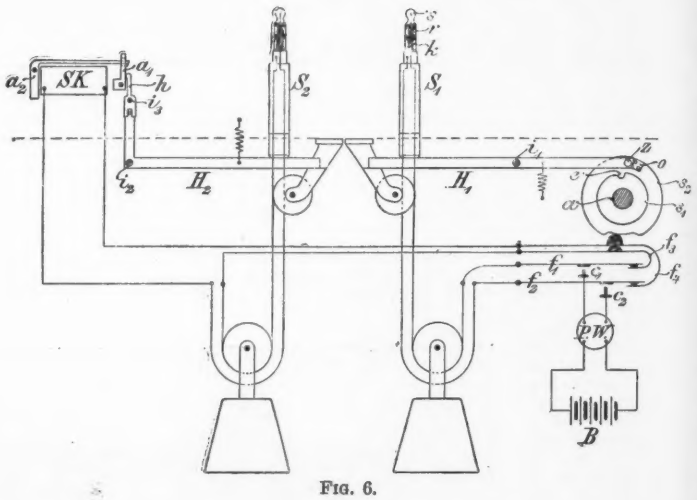


Fig. 6.

Starting with this number, the size of a section is arrived at in the following way: Suppose an exchange with 10,000 subscribers, then on a busy system and allowing for the necessary spares, about 1,300 cords will be necessary to cope with the calls at the busiest time of the day. Dividing the 10,000 subscribers on the present system into 10 sections of 1,000 subscribers each, we have 44 tables according to the above-mentioned series of connection boards, which, each with 30 cords, will give a total of 1,320 cords, more than sufficient for the service, so that as a matter of fact each section may comprise 1,000 subscribers. Naturally, this number will vary somewhat according to the exigencies of the business; generally speaking, it will lie somewhere between 700 and 2,000, and will be greater, the larger the system; for usually the increase in business does not keep pace with the growth of a system, but always lags a bit behind.

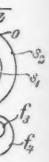
The above-mentioned experimental installation had 800 subscribers per section. The illustration (fig. 3) shows the first table, ab, considered as the beginning of the series of connection boards, capable of taking 30 double communication cords, and at the back the two jack panels, a and b, each with 800 jacks. The dimensions of the switchboard are governed by the necessity of freedom of movement for the operators, and the breadth of each table has been taken at 25½ inches. Owing to this breadth, and the small number of jacks in a panel, the individual jacks can be placed some distance apart, which is an important advantage; the individual strips of jacks, of which there are 25 in each strip, are separated from each other by thin yellow-wood fillets, and the groups of a hundred by wider white fillets, so that it is easy to locate the jack wanted. The construction of a strip of jacks is shown in fig. 4; the springs, f_2 and f_3, which carry the only contacts to be interrupted, are placed on edge, and provided with platinum contact-pieces. Moreover, the contact is a rubbing one, since when the two springs touch, f_2 yields somewhat; accordingly, the deterioration of the contacts is avoided as far as possible. The bar, s, corresponds to the line, L_4, in fig. 2.

The peg is shown in fig. 5, which can be clearly understood without further explanation.

The above-mentioned automatic arrangements comprise a simple arrangement of levers for automatically restoring the indicator, and a commutating device which comes into action when the line wanted is pegged, and sends a calling current through it for about 4 seconds. Both these devices are shown diagrammatically in fig. 6. The front peg, s_{1_1}, of each pair rests on a straight lever, H_1, which can rotate about a fulcrum at i_1; at the front end of this lever is a pin, z, projecting sideways. On the axle, a, which is continually rotated by a small motor, and makes one revolution in about 5 seconds, are placed friction-tight the two rigidly-connected discs, s_1, s_2, which thus tend to turn with the axle, a. So long as H_1 retains the position shown, this rotation of the discs is prevented by the stop, o, on the disc, s_2, bearing against the pin, z. On lifting the peg, s_{1_1}, the lever, H_1, turns about i_1, and the pin, z, drops until it lies on the periphery of the disc s_1; the stop, O, is thus set free, and both discs, s_1, s_2, rotate with a, depressing the springs, f_3, f_4, and allowing the springs, f_1, f_2, to fall upon the battery contacts, c_1, c_2; at the same time the connection between f_1 and f_3, and between f_2 and f_4 is broken. Accordingly, a calling current is sent from the battery, B, through the reversing switch, P, W, over the line which is pegged. This current lasts, as has been said, about four seconds, until the discs have rotated so far that the insulatad knot between f_3 and s_2 again falls into the notch in s_2, when the contacts return to the positions shown in the diagram; a moment later the notch e reaches the pin z, which falls into it, and stops the rotation of the discs, s_1, s_2. When conversation is finished, the peg, s_{1_1}, again falls on H_1, and turns it back into the position shown, freeing the discs, s_1, s_2, and allowing them to rotate a little further, until the stop, o, strikes against the pin, z.

(To be continued.)

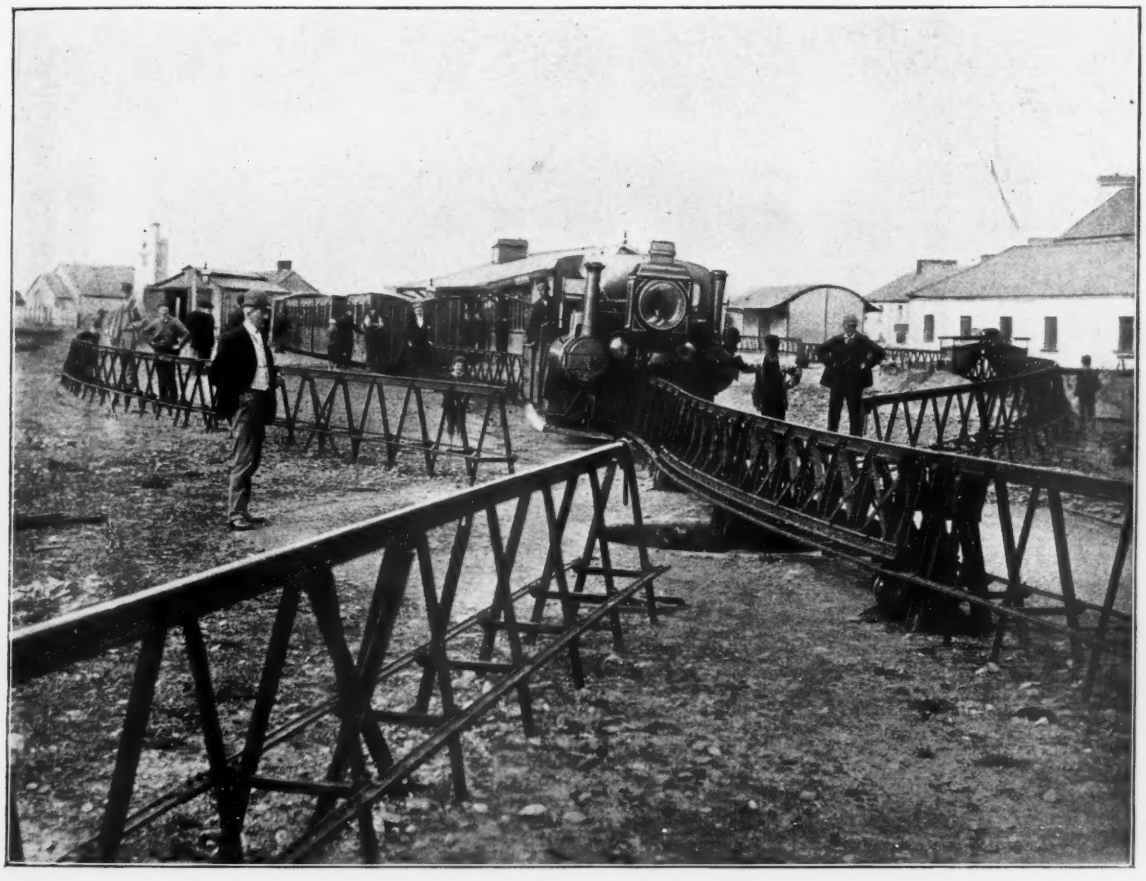
The International Pacific Cable Company.—We give below an extract from an Australian paper, which reports an interview with Mr. Audley Coote, who, we believe, acted as agent for the French company, which, being subsidised by New South Wales, Queensland, and the French Government, laid a cable from Australia to New Caledonia. Mr. Coote points out to his "interviewer" that the French Government had lately granted a special concession to his company—La Compagnie Française des Cables Télégraphiques—of £40,000 a year to lay a cable from Brest to New York, and a branch line to the West Indies, and states that the main Atlantic cable is to be worked in connection with the Pacific cable to Japan and Australia. Mr. Coote is further reported as follows in reply to his questioner:—"Would not your proposals practically hand over our cable system to a foreign nation?" "Well, for the past 17 or 18 years the Australian Governments had been bound over to the Eastern Extension Company, who charged high rates, in addition to receiving large subsidies, and it has been my aim, apparently with the desire of the Australian Governments, that this large monopoly should be broken up. As the result of an interview I had with Lord Ripon 18 months or two years ago, the opinion that I formed then was that the British Government would not be able to subsidise the Pacific cable on account of the great influence that the Eastern Extension Company had in England. If they did subsidise it they would be in a way forced either to subsidise or to buy over the Eastern Extension Company's cables, and although I have learned that a deputation of Agents-General has waited upon Mr. Chamberlain, the present Minister for the Colonies, and he has partly promised that the British Government should do something towards assisting the Pacific cable, still I feel sure that when he sees his permanent heads, and the position of affairs is explained to him, he will find that the British Government will not give their assistance to the Pacific cable, as the Agents-General have been led to hope. The Bill that I have before the United States Congress provides for a company that has been formed, and is known as the International Pacific Cable Company. On its board of directors there are four Americans, two Australians, two Hawaiians, two Japanese, two Frenchmen, and two Englishmen. The construction of the cables will be made in sections; that is, the line will be laid section by section to the places I have stated. The French company will make and lay a good share of the cables, and an English company will do an equal amount of the work.



LIGHTNING EXPRESS RAILWAY SERVICE.

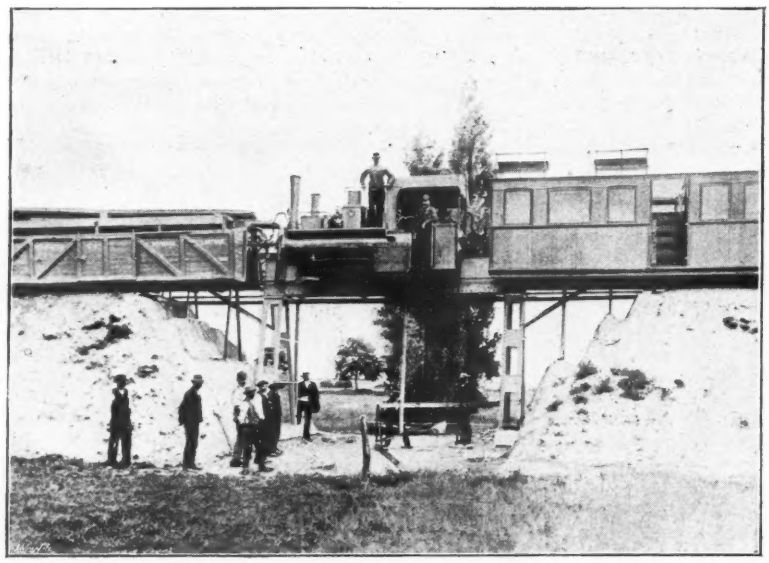
This proposed single rail line of Mr. F. B. Behr for speeds of 150 miles per hour has been exhibited in model at Windmill Street, London, W., but we are unable to see more in it than we did when the subject was put prominently forward some time ago. We have no fault to find with the working out of the arrangements as shown by the model as far as they go, but so far from being a single rail line this is really a five rail track, and yet a sixth is needed to make it really safe. As our readers may remember, the Behr railroad consists of a single bearer placed on a series of Λ frames. On this rail the carriage runs on a single line of wheels, bicycle fashion, and the carriage hangs from the axles of these carrier wheels on each side of the Λ frames. The electric motor is placed as low as possible, and every effort made to keep the C.G. low. On each side of the Λ are placed two rails on which run guide wheels. These wheels are, of course, horizontal and serve to take lateral stresses at curves. It is clear, however, that the C.G. of the vehicle is above these wheels, so that in rounding a curve the stress will be borne by the upper guide wheel on the concave or inner side, and by the lower wheel on the outside of the curve. Weight alone keeps the carriage down on the top rail, and we cannot but fear there will be great risk of the carriage rising somewhat on rounding a curve when the guide wheels will slip off the lateral rails. In fact, we quite doubt the suitability of the line for its special purpose of high speeds and consider it far more fitted for moderate duties. From Mr. Behr's own showing, the centrifugal force of a particle travelling round a 25 chain radius curve is, at 150 miles per hour, 1·4 times the weight of the particle. Now all this may be provided for in the vehicle, but not a word is said about passengers. Going round such a curve, an average passenger of 150 lbs. weight would be forced to the outside of the curve with a pressure of 210 lbs. It would be all right for the passengers on the outer side but the inside, or, as we will term them, the concave passengers would simply be flung across the car upon their *vis-à-vis*, and this, however pleasing under certain circumstances with curves of fairly flat radius, would be extremely dangerous with the sharper curves. Now Mr. Behr absolutely ignores the passengers. Super-elevation of the track, or the Behr equivalent of super-elevation, will not help the passengers much. Full super-elevation would simply make a passenger sit tight to the tune of his own weight plus 1·4 times his weight. The present writer would weigh 360 lbs. for the nonce. Our worthy editor in such a case would weigh about 520 lbs. These are serious figures. They show what great overturning efforts are made upon the structure. We think too that Mr. Behr is far too hopeful when he assumes that the centrifugal and wind stresses will be distributed over a length of 500 feet, or ten times the car length.

If, therefore, this system is to be of any practical use for high speeds the curves must be of great radius and the line generally as straight as possible. But when we have got to this we find that such conditions are eminently suitable for the ordinary railway whose trains do not leave the track at high speed on straight portions, and whose simplicity and cheapness of construction far exceeds that of the Behr system. Again, as regards accident, we cannot, despite Mr. Behr's argument, admit that the risks are anything so light as he infers. We do not care to contemplate the fearful result of a failure in the continuity of the structure with the central rail running as it does through the centre of the car. An accident might be productive of most serious mixing up of the iron structure, the car, and the passengers. The fact is that Mr. Behr has paid so much attention to the mathemathics of the mere structure, looked at as a girder, that he has overlooked that passengers are not part of the general structure and cannot be thus mathematically disposed of. As a mere question of stability and strength, such a line can be established just as easily as any other



View of Listowel and Ballybunion Railway, Ireland. Lartigue System.

girder structure. Mr. Behrs own words amount to a platitude. They are: "To secure perfect safety it is, therefore, simply necessary that the lateral bending movements of the rail and guide rail, and the resistance of the rail girder shall be sufficient to absorb—the excess of centrifugal force." Absorb is good. The statement reminds one of the now common idea that to reach the North Pole one has simply to travel there in a balloon. Quite so, we answer, to both statements, but in each case the difficulty is the passenger, and the Behr railway at 150 miles per hour is impossible just on the very points where it is supposed to overcome the difficulties of the common railway. There is no limit to speeds for Behr's system if suitably constructed to carry goods properly packed, but passengers cannot be so packed for ordinary traffic. If high speed is demanded and passengers would pay for it, they could be carried lying down, and in this way alone the stress per unit of length would be moderate, but the same outlay would build a straighter line, and the virtue of the Behr system would be gone. For a light line, winding in and out of crooked places and at moderate speeds, we think there is room for the system, electrically worked or otherwise, but more than this we do not care to say.



View of the Railway from Feurs to Panissieres, France. Lartigue System.

View of the Listowel and Ballybunion Railway, Ireland. Lartigue System.

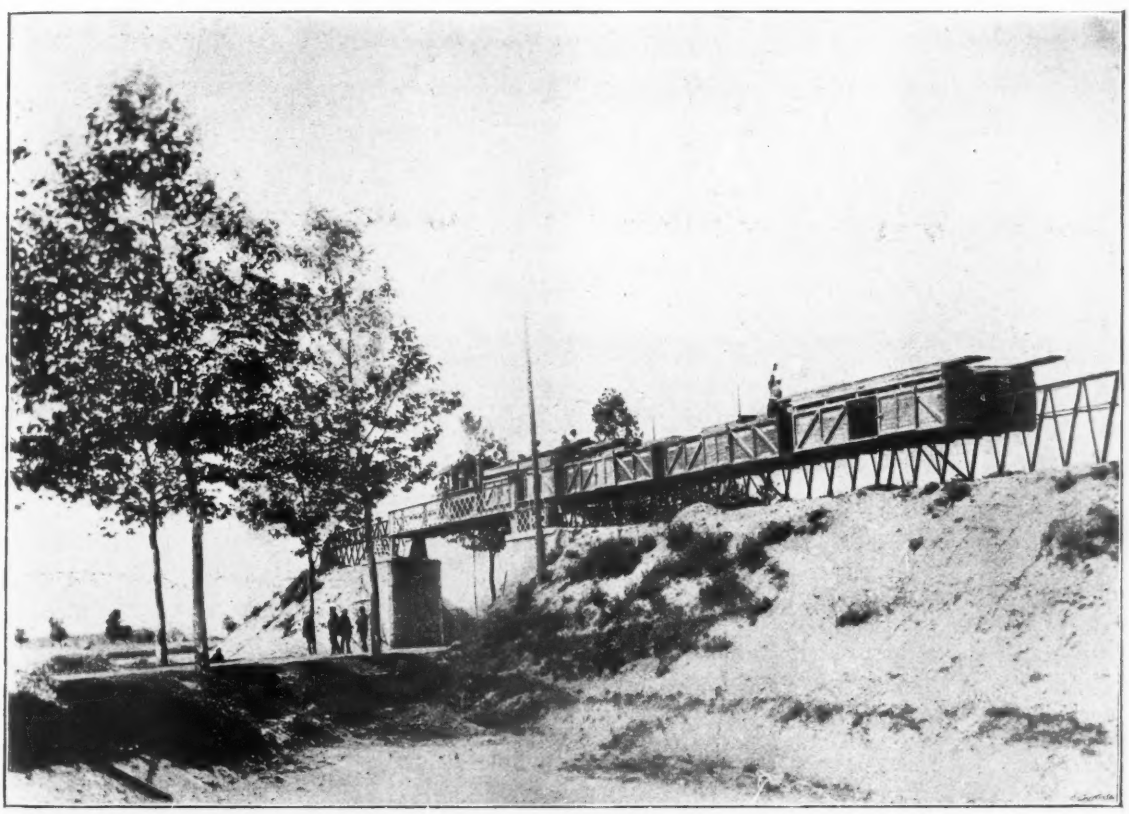
However, Mr. Behr's method has been public property for several years, and we have pleasure in reproducing several views of the Listowel and Ballybunion Railway in Ireland which has been constructed on the system, but has so far been worked by steam locomotives at low speeds. With a view to the system being adopted for electrical working, a trial track of three miles is to be laid down at Brussels so as to be ready for the exhibition of next year. This line will take the form of an oval with circular ends of 550 yards radius, and the speed is said to be guaranteed to 95 miles per hour. Mr. T. Parker, of Wolverhampton, is, we believe, to have the design and management of the electrical details.

As regards the general arrangement of the car, this has now been arranged so that the seats are above the apex of the rail structure, and the general centre of gravity of the whole is brought low by placing the motors in the lowest part of the carriage sides, connecting them up so as to partake of the motion of the springs while maintaining a fixed distance between the centre of the armature and that of the axles. From the pamphlet supplied to us, it appears that cars of 50 feet are intended, carried on bogey trucks, and with motors equal to 600 H.P. each car. At 2 feet 3½ inches below the surface of the apex rail of the trestle structure there is cross bracing, and on each side of the trestle guide rails, four in all. Where a road or river is to be crossed the structure is suitably trussed to act as a bridge, and piers are provided where necessary. For changing over from one line to another, a piece of the structure is made to swing upon a turntable. An idea upon which Mr. Behr appears to lay considerable stress is that his line can be laid along the banks of existing railways at a small expense, but it is not explained how the structural details will be accommodated to the side-long slopes of the cuttings or embankments which vary in angle with every change of strata, and there is no railway in England on which express trains of specially high speed could ever be demanded that does not run across the upturned edges of many different strata, and not along the strike. This peculiarity belongs to all the paying railways in England—in fact, is essential to a good dividend. The structural expense of the line along ground of continually changing slope would, we feel sure, be a serious bar to the arrangement proposed. Upon this basis, however, an estimate is given of the cost of a line from London to Brighton. The whole cost of this, using existing railway banks, &c., and including full equipment for a 150 miles per hour 3 minute service, is given as not above a million sterling. It could carry at least 2,000 passengers per hour, or 10 million annually, but 2,000 passengers a day are relied upon at four shillings each, and this would yield

£140,000 per year, or £85,000 nett, equal to 8½ per cent. on the capital.

Mr. Behr contends that his trains would suppress the ordinary express traffic, and leave the existing lines free to do the heavy business; that this change will not be financially prejudicial to the line, but that present express traffic causes a greater embarrassment of general traffic than is proportioned to its relative earnings. He argues that for each express train suppressed, a slow train of a remunerative character could take its place, while the provision of the Behr line, solely for high speed service and absolutely free from the slower traffic, will not only develop the high speed travelling, but materially reduce working expenses. Mr. Behr relies, in fact, upon a large hidden and undeveloped mine of traffic which is to spring into being with the facilities he offers, but he will need to convert railroad directors first. The average railway man cannot brook the idea of the public travelling cheaply. Could they do so, and act up to it, they might tap for slow traffic an enormous untouched field.

The latest suggested vehicle is one of which the body is articulated to enable it to travel easily on curved portions of the line. It would run on 12 bearing wheels and seat 135 passengers with space for their luggage, and would weigh in full working order 60 tons, including 10 tons of passengers, each articulated length weighing 20 tons and being 25 feet long. The speed is moderated to 110 miles per hour, and the curve radius is made 35 chains. Evidently the odd figures of 150 miles and 25 chains radius are being found wanting. In Mr. Behr's model the various details are nicely worked out, and there is no mechanical objection to the running of such a railway, but the very figures advanced by him, and his care in putting the C.G. as low as possible, and generally his provision against centrifugally produced stresses confirm us in our opinion that further consideration of the same will convince Mr. Behr that he cannot separate the passengers from the vehicle, and that however much he may provide against the stresses set up in the structure or the cars by the use of high speed round curves, he will still be face to face with the difficulty of the passengers.

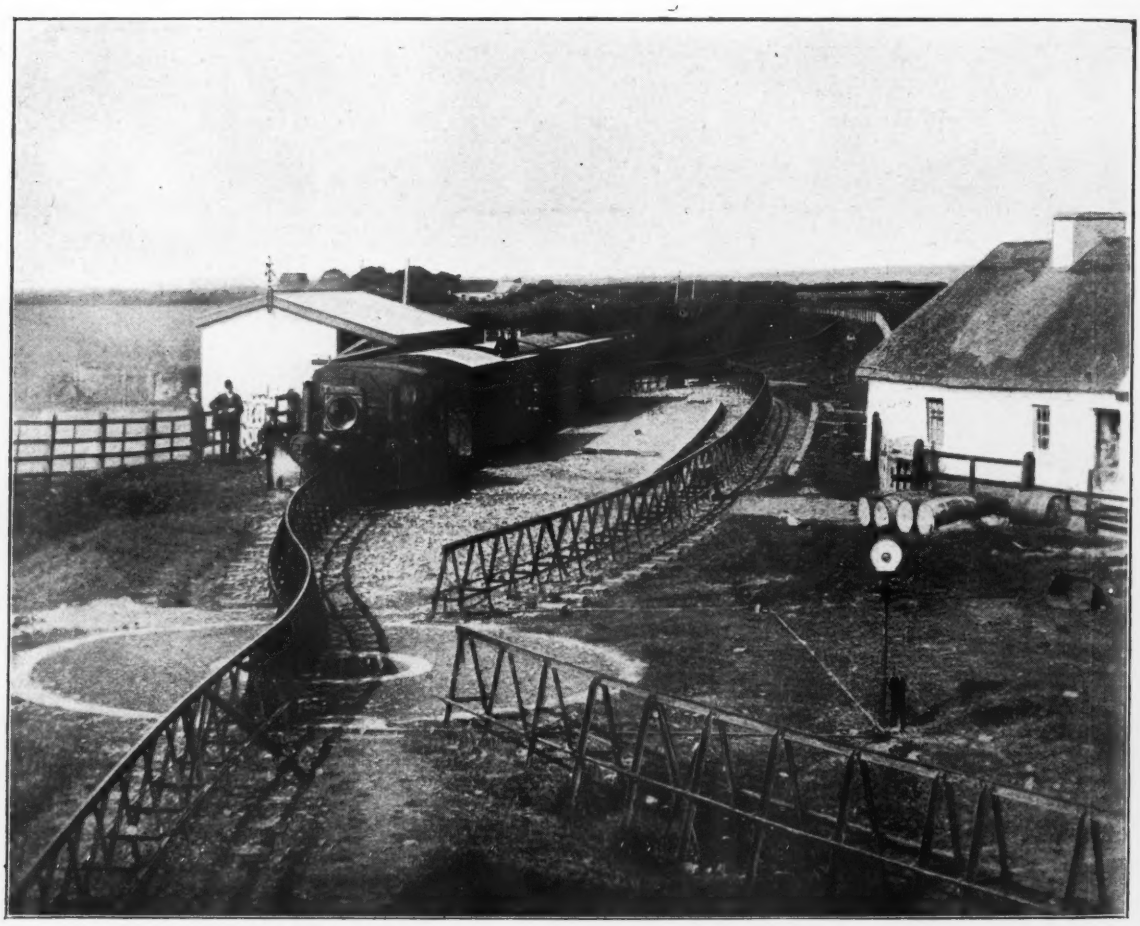


Railway from Feurs to Panissieres. Lartigue System.

FUEL PROBLEMS.

In an address delivered before the American Institute of Mining Engineers, Mr. J. D. Weeks calls attention to the waste of coal and of its constituents which goes on from the moment the miner first attacks it with his pick. We believe that the mining waste he estimates is by no means so serious in England, at least on the long wall system of mining, whereby theoretically every particle of coal is capable of removal. He states, however, that not more than 30 per cent. of the coal in the mine has arrived at the point of consumption during the past fifty years. A good deal of American mining is conducted on very unscientific principles, and half the seam is frequently left behind because of some slight inferiority of quality. Fuel may be saved by improved methods of burning and by improved engines and regeneration, but besides the waste of fuel there is that of its bye-products. Taking the operation of coking as an example, every ton of coal coked in the United States may fairly be assumed to produce 3 per cent. of tar, worth one-sixth of a penny per pound; one per cent. of sulphate of ammonia, worth three half-pence per pound; one half of one per cent. of benzole worth one penny per pound; and one pound of cyanide of potassium worth 25 pence. From the 15 million tons coked in 1893, the bye-products

would have been worth over 4 millions sterling. But 113 millions of coal were otherwise used in the same year—1893. What about the value of the products from this amount of coal? Referring to the Mond circular producer which he had seen in England, Mr. Weeks states that it yielded 105 lbs. of sulphate per ton of Yorkshire coal and gave regularly 80 to 90 lbs. Whether possible at present we cannot say, but the possibilities are great, and the inference we are left to draw is that all coal should be utilised in the form of gas, and the valuable assets recovered. Indications are already at hand pointing to this end being secured. In a country, like England, of short distances, the whole of the fuel consumed in the smelting of iron, with the exception of the very small percentage that is lost in the fusion of the ore, is really available for purposes of light and power. We say short distances because the occurrence of large cities within a few miles of the iron producing districts obviates the expense of long leads, and there is no large city in England, probably few small villages for that matter, which is not nearer to an iron furnace than the distance over which electrical energy has been already carried by conductors. The envious and half-informed tariff-protected foreigner who endeavours to divert Englishmen from their free trade policy is sufficiently alive to our unique and unrivalled natural advantages of position and climate to wish he enjoyed them, and though he has not sufficient manhood to come out from behind his wall of tariffs, he is envious of us who have no tariffs. He may make temporary inroads upon our markets, but we have recently had some very convincing proofs that where quality is demanded foreign competition fails. Every improvement foreshadowed by Mr. Weeks in the best economy of fuel will find its best field in England, where, as we have said, the distances are small and the coal fields are variously dotted over the country.



Listowel and Ballybunion Railway. Lartigue System.

EXPERIMENTS ON LATENT HEAT OF STEAM.

Dr. Harker of Manchester, has recently presented a paper to the Literary and Philosophical Society of that city on the latent heat of steam. Some preliminary experiments made by him in conjunction with Mr. P. J. Hartos with a modified form of the apparatus designed by M. Berthelot, showed a difference of $2\frac{1}{2}$ per cent. below the now classic figures of Regnault, published in 1847. Except Berthelot's own results none others have confirmed the work of Regnault, and this was Dr. Harker's aim. In a series of experiments the majority confirmed the low figure of the preliminary tests, but one or two came out higher and approximated to Regnault's figures. The thermometer by Baudin of Paris was proved accurate. To test the boiler for priming, a 5 per cent. solution of permanganate of potash was used in it, and the distillate examined calorimetrically in Nessler glasses, and no trace of colour could be traced, though 1 part in 10,000 would have been appreciable.

Did the steam lose heat on its way to the calorimeter? This was more difficult to decide. Obviously the path of the steam should be the shortest possible. To get over the trouble connected with the source of heat a novel idea was employed. The heat was furnished by a coil of wire through which an electric current was passed, the wire being fully immersed in the boiler. The steam pipes were jacketed with the small lead pipe known as twigging in the trade. Steam was passed through this insulation from a second boiler, and thus the pipes were jacketed against radiation losses. The author goes minutely into the various precautions taken to ensure accuracy, including a description of a slight superheating device, and, as a mean of experiments, obtained the result, 640·9, with steam superheated. Without

superheating three experiments gave 639·0, but he omits these as the dryness of the steam was doubtful.

The value, 640·9, is the heat necessary to raise one gramme of water from 0 to 100°, and evaporate at a barometer of 760 mm.

Taking off the 100·5 units as the heat used in raising the water to 100°, we get 540·4 as the true latent heat, a number differing very little from that of Regnault.

Mr. Griffiths calculates from his investigation of latent heat at temperatures below 100°, that at 100° the latent heat is 536·6, assuming that the latent heat, L, is a linear function of the temperature. This remarkably corroborates the results of Regnault obtained nearly 50 years ago, and it is hoped Mr. Griffiths will extend his observations between 10° and 60°, as there is reason to doubt Regnault's figures for the value of L when T is less than 100°. Finally, Dr. Harker is strongly in favour of large apparatus. The more he attended to the care of details designed to guard against loss the nearer did he approach to Regnault's figures. May we not hope that some other observer will do for the specific heat of steam what Regnault so beautifully did for its latent heat.

CORRESPONDENCE.

Johnson & Phillips's Arc Lamp.

A contemporary having made a statement to the effect that Brockie-Pell Arc Lamp (Limited) has been formed for the purpose of taking over part of our business, we shall be glad if, by the courtesy of the editor of the Electrical Review, we are allowed to inform our customers and friends that the company referred to leaves our business alone, taking over from us only Messrs. Brockie & Pell, in whom we cannot claim to have proprietary rights. The company, we understand, has been formed for the exploitation of certain of Mr. Brockie's patents for which we did not see our way to make an offer, but our name did not appear in the prospectus; we have no interest in the concern, nor do we consider that our business in arc lamps will be *adversely* affected by it. We shall continue to manufacture our lamps as before, bestowing upon them that care in make and finish to which their great success in the past has been due. It may be difficult for experts to detect the difference between our lamp and that known up to the present as the "Brockie-Pell," but to our customers the difference will be apparent, inasmuch as the price of ours will now be reduced by the amount hitherto paid in royalties.

Johnson & Phillips.

August 4th, 1896.

SOME CURIOUS FIRES CAUSED BY ELECTRICITY.

The following instances of fires arising from electrical causes are taken from a recently published American Fire Office report:—

Short Circuit in Flexible Cord.

A flexible cord supporting a lamp, which was not burning at the time, suddenly developed a short circuit and a one ampere fuse in a rosette opened cutting off the current. The rosette worked perfectly, and 10 ampere fuses in the branch block were not blown. The system was 115 volts direct current from an isolated plant. The cord was quite greasy with oil coming from shafts and bearings, and dirty with lint which had accumulated. The risk was a cotton mill. The arc, though almost instantly cut off, was sufficient to set the cord on fire, and several inches of it were burned. The fire was quickly extinguished by an attendant, so that practically no damage was done. A few days before this accident, another cord developed a short circuit under practically the same conditions. In both cases the cords were hanging free in the air and had not been touched for a number of hours. It is the custom at this mill to frequently turn on and off the lamps by the key sockets and also to frequently brush the lint off the cords. During the summer season the cords are wrapped together and tied in a bunch near the ceiling to get them out of the way. The best explanation of the trouble is that a strand of the fine wire broke and pushed its sharp end through the insulation causing the short circuit. Both cords had one or two layers of cotton thread first, then a fairly thick outer covering of silk, but they were not rubber covered. These occurrences show that however quickly currents may be cut off by fuses, the heat generated by the arc is sufficient to set fire to flexible cords, especially if they are at all greasy and covered with lint. The need of better cords is also plainly shown. A better cord may not mean one having a higher insulation, but rather one which could not be set on fire. It seems important that cord should be used which would prevent short circuits occurring under as great a number of conditions as possible, and at the same time prevent the flash produced by a short circuit from doing harm.

We believe Mr. Musgrave Heaphy has frequently pointed out the dangers that might arise from a careless use of flexible cord.

Another instance is worth quoting from the report, which we will call

The Cost of a Short Circuit.

A short circuit occurred in the wires leading to a 24-light electrolier. The flash of the arc was noticed by several persons, but on account of the extreme height of the ceiling and there being no high ladders handy, nothing could be done to extinguish the flame resulting from the fusing of the wire. The fire gained great headway before the Fire Department arrived, and it took four hours of hard fighting to get the flames under control. The electrical inspector made an inspection next morning and discovered copper wire in some of the cut-outs instead of fuses. A detailed report of defects in this equipment had been furnished to the owner some time previous to the fire, but he had positively refused to do anything towards making the wiring safe. The loss was estimated from 50,000 to 70,000 dollars.

It is very alarming to find that from January 10th to April 10th of this year there were 115 fires in America caused by electricity, the total damages being 293,000 dollars.

Yet the majority of these were directly traceable to careless workmanship.

BUSINESS NOTICES, &c.

Electrical Wares Exported.

Week Ending Aug. 4th, 1895.	£	s.
Adelaide	7	0
Aden. Teleg. mtl. ...	1,175	0
Alexandria	105	0
Algoa Bay	108	0
Amsterdam	10	0
Barcelona	312	0
Bombay	137	0
" Teleg. mtl.	203	0
Brussels	40	0
Buenos Ayres	319	0
Calcutta	72	0
Cape Town	56	0
Colombo	173	0
Copenhagen. Teleg. cable	342	0
East London	1,714	0
Gambia	420	0
Geraldton. Teleg. mtl.	651	0
Gothenberg	80	0
" Teleg. mtl.	72	0
Malta.	42	0
" Teleg. mtl.	100	0
Melbourne	75	0
Rangoon	45	0
St. Petersburg. Teleg. mtl.	450	0
Shanghai. Teleph. mtl.	34	0
Stockholm. Teleg. cable	134	0
" " wire	128	0
Sydney	45	0
Wellington	19	0
Yokohama	8,952	0
Total	£16,020	0

Week Ending Aug. 4th, 1896.	£	s.
Alexandria	700	0
Amsterdam	11	0
Antwerp	38	0
Bombay	10	0
Boulogne	15	0
Brussels	519	0
Calais. 5 tons Teleg. wire	no value declared.	
Cape Town	589	0
Colombo. Teleg. mtl. ...	145	0
Durban	705	0
East London	246	0
Genoa. Electric launch	220	0
Gothenberg	63	0
Hong-Kong. Teleg. mtl.	1,530	0
Melbourne	309	0
" Teleg. mtl. ...	325	0
Nagasaki	32	0
Ostend	83	0
Passages	45	0
Penang. Teleg. mtl. ...	331	0
Perin	28	0
Port Elizabeth	197	0
Shanghai	1,247	0
Singapore	180	0
Stockholm	195	0
Sydney	858	0
Wellington	67	0
Total	£3,688	0

Auction Sale.—As will be seen in our "Official Notices," Messrs. Percy Huddleston & Co. will, on Tuesday next, August 11th, sell by public auction at the Crown Hotel, Booth Street, Manchester, two 16-H.P. gas engines, two 300-light compound dynamos, and a variety of other electrical plant and accessories.

Brockie-Pell Lamps.—Mr. Bennett Pell, the managing director of "Brockie-Pell Arc Lamp, Limited," informs us that all orders for Brockie-Pell patent arc lamps should now be addressed to the offices of the company, 14, Gracechurch Street, London, E.C. Mr. Pell has resigned his position with Messrs. Johnson & Phillips as and from the 5th inst.

D.P. Battery Company, Limited.—At the general meeting of the D.P. Battery Company held the other day, a dividend of 19 per cent. was declared for the past year. We are informed that in view of the profits that have resulted, the price of the battery is to be lowered, so as to give further encouragement to contractors to adopt this accumulator. It is very gratifying to note this.

Personal.—Mr. G. S. Wilson informs us that he has severed his connection with the Zurich Incandescence Lamp Company, of 47, Victoria Street, S.W., whom he has represented for the past 18 months all over England, Ireland and Scotland, and has made an engagement to represent another large firm of incandescent lamp manufacturers making a speciality of high voltage lamps, which will be advertised shortly.

The Sunderland Forge and Engineering Company.—This company is erecting, in contiguity to its existing works at Pallion, new electrical works, where electrical engineering contracts will be carried out. The works will be complete in October. Dynamos, motors and cranes are already being made there.

ELECTRIC LIGHTING NOTES.

Acton.—Mr. Goddard and Mr. Cohen are to attend before the District Council with reference to the purchase of Mr. Cohen's electric lighting works.

Bedford.—The County Council has resolved to introduce electricity into the Shire Hall for lighting, and a Sub-Committee has been appointed to decide upon a firm to do the work.

Belfast.—The Electric Committee reports having had under consideration the necessity of increasing the present gas-driven plant in the central station, as that now available will in all likelihood be fully utilised before the extension of the system as proposed can be taken in hand. The engineer's report shows a fair surplus over the working expenses.

Bridgwater.—The question of lighting Bridgwater by electricity is under consideration.

Bristol.—The Local Government Board inquiry regarding the loan of £75,000 for electric lighting extensions, was held on 29th ult.

Bury St. Edmunds.—The Council has decided to adopt a scheme for electric lighting. The estimated outlay approaches £20,000.

Coventry.—Councillor West moved at the last Council meeting, that the streets in the central part of the city be lighted electrically, but the motion was rejected by ten votes to five.

Edinburgh.—After a very lengthy discussion, the other day, on the subject of a proposed renewal fund, the Town Council passed the following resolution unanimously:—"That the question as to the disposal of the moneys received from the electric light undertaking raised by the motion of Councillor Mackenzie be remitted to a joint conference of the Electric Lighting, Treasurer's, and Law Committees, with power to take the opinion of counsel."

The Police Accounts, which have just been issued to the members of the Corporation give the following particulars regarding the electric lighting undertaking:—Receipts, £17,050; expenditure, £7,165.

Electric Light in Printing Works.—Messrs. Drake and Gorham have, we understand, been successful in obtaining the contract for the lighting of the works of Strine's Printing Company in Derbyshire.

Esk (Durham).—The Esk Parish Council has before it a proposal to light the Langley Park and Uskan Moor districts by electricity, and Quebec by oil lamps.

Exeter.—At the quarterly meeting of the Devon and Exeter Hospital Governors, Mr. Franklin stated that he believed the hindrance to the acceptance of the tender of the City Council for the electric light was because the Council could not give a continuous current supply.

Fort William.—The works in connection with the Fort William Electric Lighting Company, Limited, are now nearing completion. So far advanced is everything, that on Saturday and Sunday the light was turned on in the accumulator house. The street cables have been laid, and the overhead wires are all but completed, and it is anticipated that all the churches, hotels, and private houses which have already been wired will be connected within the next fortnight. The Station Hotel is to be illuminated throughout from the company's works, 350 lights being fitted.

Germany.—The German military authorities are reported to have decided to establish a large central station for the electric lighting of the whole of the military works at Spandau, of which only a part are at present so lighted.

Glasgow.—The Town Council is using its gas surplus in a very wise way, for it is devoting £962 thereof to the electric lighting of the Town Hall.

Godstone.—The East Grinstead Electric Lighting Company has given notice of its intention to apply for a provisional order for lighting the district, and to include a part of Lingfield.

Leyton.—The committee have considered the applications received for the appointment of resident engineer (53 in number), and have selected six candidates to attend the next meeting of the Council in General Purposes Committee. The committee recommend that the resident engineer, when appointed, be authorised to appoint (in consultation with Prof. Robinson) an engine driver at a salary of £2 2s. per week, and two attendants at £1 5s. per week each. The committee have received a quotation from Messrs. S. Z. Ferranti, Limited, for meters to be supplied to private consumers, and recommend that 10 ampere meters, at £6 10s. each, be supplied, subject to a discount of 15 per cent. The Council considered these recommendations last week, and appointed Mr. H. C. Bishop, of Bristol, resident engineer at £156 per annum.

Liverpool.—The Lighting Committee has instructed Mr. A. B. Holmes, the electrical engineer, to carry on the manufacture, sale, and fixing up of fittings as before. If, however, applications come from outside the area for fixing fittings, such will be placed before the committee for consideration.

London.—At the last meeting of the Commission of Sewers, Mr. H. T. Gordon called attention to the fact that the transformer and other boxes in connection with the electric lighting of the City had not been filled with wood or sacking in order to minimise the risk of explosion through accumulation of gas. Mr. Voysey, the electrical inspector, stated that only some of the boxes had been filled with wood; under the regulations of the Board of Trade the company were not required to fill the boxes. Mr. Gordon asked whether instruction was not given to the electrical inspector to see that the boxes were filled. He believed instruction was so given. Mr. Voysey, in reply, stated that he had not received such instructions, and he had reported on the subject, recommending the making of experiments. He considered that it was the Board of Trade, and not the Court, who should say what measures were to be taken; the Commission had not the power to do so. In answer to Mr. Greenwood, he further stated that the boxes to the number of 2,000 weekly were regularly inspected by the Board of Trade. On the motion of Mr. Gordon the matter was referred to the Streets Committee.

Manilla.—Some interesting particulars of the cost of lighting Manilla by electricity were given to a *Rangoon Times* reporter by Mr. Hilles, of the firm of Bagnalls & Hilles, electricians, of Singapore, New York and Yokohama, who had the contract. Manilla pays the firm $62,000 a year for 1,000 20-candle-power incandescent lights, and 140 lights of 2,000 candle-power each. For private consumers the cost of a 16 candle-power lamp for an all night circuit is $3 per month, and for half a night $1½. Mr. Hilles says Rangoon has the great advantage of a saving of 40 per cent. in fuel, if it uses paddy husk. Manilla has diminished its crime by improving its light, whilst citizens now "bicycle" at night in ease and security, undisturbed by lawlessness. Formerly few respectable people used the streets after 8 p.m. Now they are a favourite nightly resort.—*Indian Engineering.*

Mile End.—The County of London and Brush Company intends applying for a provisional order for lighting the Old Town electrically.

Mill Lighting.—The contract has been obtained by Messrs. Drake & Gorham for the large extension of the electric lighting at Messrs. Tootel, Broadhurst & Lees, Daubhill Mills. The work is being carried out by the Manchester branch to the specification prepared by Mr. William Druce, consulting electrical engineer, of Manchester.

Omnibus Lighting.—The Compagnie des Omnibus of Paris is making some experiments in connection with the electric lighting of its vehicles.

Peterborough.—Messrs. J. A. Robertson and Co. inaugurated their electric light installation at their Bridge Street premises on Saturday week in the presence of a number of members of the Corporation and other citizens. The dynamo is driven by a high-speed engine. The shops are lighted by Ediswan incandescent lamps, and 1,000 C.P. arc lamps light the interior and exterior of the riding school.

Reigate.—The Town Council intends applying for a provisional order, and will oppose the application of the Guildford Electricity Supply Company if it is not withdrawn. Copies of correspondence, and Mr. Medhurst's report, are to be printed for the members.

Stoke Newington.—The County of London and Brush Provincial Electric Lighting Company, Limited, intends to apply, on or before December 21st next, for a provisional order.

Spain.—Tenders were lately invited for the contract for the electric lighting of the public streets of San Celona (Barcelona province) during a period of 10 years; but a correspondent informs us that not a single offer was received.

South Africa.—The August number of the *British and South African Export Gazette* says that Messrs. George Findlay & Co., electrical engineers, recently erected two large arc lamps in the process engraving works of Messrs. Dennis, Edwards & Co., Capetown. —An electric lighting installation is to be obtained for the Johannesburg railway stations and goods yards.—We understand that, owing to the delay of the Johannesburg Sanitary Board in supplying the power for the electric lighting of Goldreich's Buildings, the directors of the company are considering the question of obtaining a generating plant of their own.—The generating station for the electric lighting of Cape Town is, we are informed, fitted with two 250-H.P. turbines, two 130,000-watt Siemens & Halske dynamos, two compound jet condensing 250-H.P. engines, and two water-tube boilers. The system in use is the "five-wire."—We hear that the directors of the York mine are obtaining a large electrical installation for their property.—An electric pump is to be obtained to pump the solutions into the vats on the New Midas Estate as soon as the electrical installation is complete.

Walsall.—St. Matthew's Parish Church is now lighted electrically, Messrs. Bailey Brothers, having fitted up the building under the superintendence of Mr. Spurrier.

Willesden.—Regarding the Vestry's intention to oppose the application of the Willesden Green Electric Supply Company, the company has written suggesting an interview, in order to arrange terms. The Vestry, however, declines to agree to this.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Belfast.—The report of the Belfast Street Tramways Company for the half-year ending June 30th contains the following paragraph:—"The directors regret that up to the present they have not been able to come to terms with the Corporation for the working of the Belfast tramways by electric traction. In the meantime the company's Bill, authorising the use of electric traction, has been passed, but subject to the sanction of the Corporation being first obtained. The whole matter now, therefore, rests with the Corporation."

Cairo.—The electric tramway at Cairo was successfully inaugurated last Saturday by a trial trip in the presence of the Minister of Public Works, Fakhry Pasha, and a large concourse of spectators.

Cape Town.—A Cape Town correspondent informs us that, on the invitation of the City Tramways Company, a large number of the members of the Legislature and others were present at a trial trip by electric power on the new lines. The cars proved most comfortable in all respects, and jolting was conspicuous by its absence. The engines and machinery at the power station were inspected, and, after the indispensable refreshments had been discussed, the Mayor of Cape Town said they had to thank the syndicate for the excellent work which they had done in such a short time. It was only last August that the scheme was first started.

Dover.—The Council has instructed the town clerk and surveyor to report jointly upon the motive powers of tramways, together with the cost of working the same.

Electric Railways.—In the House of Commons, on 30th ult., Mr. Elliott Lees asked the President of the Board of Trade whether his attention had been called to the danger of injury being done to existing electric lighting undertakings if electric railways should be constructed under the Light Railways Bill, unless the regulations now prescribed by the Board of Trade with regard to electric traction were amended so as to include precautions to prevent the currents of existing electric lighting undertakings being affected by the currents of electric railways; and whether he was prepared to amend these regulations. Mr. Ritchie replied that it would be the duty of the Board of Trade to see that there were inserted in the Order authorising a light railway proposed to be worked electrically, such provisions to secure public safety and the interests of electric lighting or other undertakings as they might deem advisable. If it was necessary to amend the existing regulations they could be amended in the order.

France.—Negotiations are in hand in reference to the construction of two lines of electric tramways in the town of Poitiers.

Glasgow.—On 29th ult., the Tramway Committee of the Corporation considered a recommendation of the sub-committee to introduce the overhead electric system from Mitchell Street to Springburn. The recommendation further stated that the generating plant should be placed in the present Springburn depôt, which is close to the track, and admits of the minimum cost for feeders and returns. The following is an estimate of the cost of equipping this section, measuring about 2·45 miles of double track, for a three minutes' service:—

Overhead construction and rail bonding...		£3,300
Power house...		2,000
Generating plant		6,000
Feeders		2,200
15 new motor cars, at £550 each...	£8,250	
Less cost of 15 ordinary cars required and hereby superseded at £145	2,175	
		6,075
		£19,575

Eight members voted for the proposal and eight in favour of an amendment by Mr. Martin, that the consideration of the matter should be delayed to allow of fuller inquiries being made. The committee resolved to adopt the recommendation by the casting vote of Mr. Walter Paton, the chairman.

Pretoria.—Pretoria is going ahead, says the *Financial Times*, and is now preparing to go one better than Johannesburg in the matter of its railway service. The Pretoria Tramway Company has obtained permission from the Government to substitute electric motive power for horse-power, provided the townspeople express themselves in sympathy with the proposed change, and petitions in favour of the scheme are now being actively circulated in the capital. The plant has already been ordered from England, and work is expected to be commenced early next month. The cost of construction is estimated at something like £8,500 per mile, and the company is of opinion that by electrical power the trams can be run much more economically and satisfactorily than by horses. The company has a capital of £65,000, in £1 shares, 15,000 of which are held in reserve. Mr. Johann Rissik, Surveyor-General, is the chairman of the company.

Reading.—The directors of the Tramway Company, in their report, state that for some time past they have had in preparation proposals for the conversion of the tramways into electric lines, and concurrently extending the tramways into other parts of the town. These proposals will in due course be submitted to the Town Council for consideration, and the necessary powers applied for.

TELEGRAPH AND TELEPHONE NOTES.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired.
Brest-St. Pierre (1869, Anglo)	April 6th, 1895 ...	...
Puerto Plata-Martinique ...	Dec. 19th, 1895 ...	...
Monte Alegre-Santarem ...	May 5th, 1896 ...	...
Bissao-Bolama	May 30th, 1896 ...	...
Shanghai-Nagasaki	July 23rd, 1896 ...	August 2nd, 1896
Gibraltar-Tangier	July 28th, 1896 ...	...
Landlines.		
Trans-Continental line beyond Mazol (Mashonaland)	March 12th, 1896 ...	...
Bolinao-Manila	March 19th, 1896 ...	May 20th, 1896.
Communication with Cartagena and Barranquilla, Columbia.	July 4th, 1896 ...	...
Communication with Cuenca, Machala, Santa Rosa, Loja, and Guaranda	July 10th, 1896 ...	July 26th, 1896.
Salisbury-Umtali (cutting off communication with Beira)	July 10th, 1896 ...	...
Moulmein-Bangkok	July 28th, 1896 ...	...

Field Telegraphy in Volunteer Practice.—The *Daily Mail* says that at Aldershot the telegraph wagons of the Royal Engineers have been placed at the disposal of the Telegraph Company of the Post Office Rifles, composed of trained telegraphists, in order that they may practise laying out land lines after the manner of the Royal Engineers.

The Telephone System.—The *City Press* says that for the improvement of the telephone service in London, Leeds, Dublin, Manchester, and Liverpool a sum of no less than £200,000 is proposed to be expended by the National Telephone Company.

The Islet of Trinidad.—It is stated that the British Government has, after lengthy negotiations, recognised the sovereignty of Brazil over the islet of Trinidad.

The New French Atlantic Cable.—From papers which have reached us, we learn that the subscription list for 45,000 4 per cent. debentures, each of 500 francs, in the Compagnie Française des Cables Télégraphiques, was opened to the public in France on August 5th. This company already owns the ("P.Q.") cable which unites Brest with St. Pierre-Miquelon and the United States, and which, as is pointed out in the prospectus, is the only cable which France possesses for the transmission of her American and West Indian traffic. The French Government has guaranteed to this company an annual subsidy of 800,000 francs for 30 years, on condition that a new trans-Atlantic cable be laid from Brest to Cape Cod; as well as a branch or extension line joining this trans-Atlantic cable with the existing system of cables belonging to this company in the West Indies, where the Islands of Cuba, Hayti, and San Domingo, the French Antilles, Curaçao, Venezuela, Cayenne, and Brazil, are already linked together, and from which system an important traffic return is expected; which return is further increased by subsidies which are paid by the Dutch and French Colonies. It is expressly stipulated in the concession that this system is to be connected with the Cape Cod trans-Atlantic cable directly and without intermediary. The price of issue of the debentures is 475 francs, which is payable as follows:—50 francs on application, 125 francs on allotment (from June 17th till August 20th), 150 francs between September 15th and 20th, and 150 francs between October 15th and 20th of this year. The drawings, to extend over 30 years, will take place in January and July of each year. The annual revenue necessary to pay off the debentures as they fall in, and to provide for the interest upon them is 1,294,558 francs, 65 cents, and is assured by the following:—Total receipts 1,650,000 francs, Government subsidy 800,000 francs, to which add 80,000 as coming to the company as its trans-Atlantic share of the traffic at present carried on its West Indian lines, but which is at present handled by other lines on the rest of the route. The gross estimated revenue thus amounts to 2,530,000 francs. The concession from the French Government is dated July 2nd, 1895, and the authorisation to issue these debentures carries date July 9th, 1896. The company have arranged with their contractors, and anticipate that the cable will be working next year. The concession does not give exclusive landing rights to the company. The cable is to be manufactured entirely on French territory, and is to be laid and managed by Frenchmen; at least one of the ships used in the laying is to be French. During the term of this concession, the French Telegraph Administration will give preference to this route for all telegrams for North America and the West Indies, not otherwise marked for some other *viâ* by the sender. The company will, on the other hand, unless they carry some other *viâ*, or unless prejudicial to rapid transmission, send by its trans-Atlantic line to France all telegrams for Europe which it may collect at any of the stations abroad.

CONTRACTS OPEN AND CLOSED.

OPEN.

Bath.—August 13th. The Corporation Electric Lighting Committee invites tenders for the supply and erection of boilers, alternators, mains, crane, arc lamps and posts. For full particulars see our "Official Notices."

Denmark.—August 22nd. Tenders are being invited by the Lighting Committee of the Municipal Council of Copenhagen, for the supply of 20,000 incandescent lamps. Tenders to be addressed to the Directeuren for Belysning, Svalsen, Copenhagen.

Halifax.—August 13th. The Guardians of the Halifax Union are asking for tenders for electric lighting and hoists, for a new infirmary to be erected at Skircoat, Halifax. Intending contractors are to send their names, to Messrs. Horsfall and Williams, architects, George Street, Halifax.

Madras.—Nov. 11th. Lieut. Col. C. C. Rawson (in charge Consulting Architects' Division) invites tenders for the lighting by electricity of Government House, Madras, including the banqueting hall and the A.D.C.'s bungalow: also for the lighting of Government House, Guindy, including the Military Secretary's bungalow. Particulars to be obtained on application to the Consulting Architect to the Government of Madras, Chepauk, Madras.

Manchester.—The Gas Committee are prepared to receive tenders for the construction of an underground electric lighting sub-station in Piccadilly. General conditions of contract, bills of quantities, and forms of tender, can be obtained on application to Mr. C. Nickson, Superintendent Gas Department, Town Hall, Manchester.

Mexico.—August 31st. Sealed tenders will be received by the secretary of the City Council of the City of Mexico, for the lighting of the city by electricity. All information and conditions of tender, plan of the city of Mexico, &c., can be obtained on application at the Mexican Consulate, Broad Street House, New Broad Street, London.

Radcliffe (Lancs.).—August 17th. The District Council invites tenders for the supply and erection of a gas engine and dynamo, for lighting the Technical School by electricity, also for wiring and fitting the buildings for the purpose. Particulars from the Surveyor, Council Offices, Radcliffe.

Roumania.—September 4th. The Municipal Authorities of Jassy, Roumania, are inviting tenders for the electric lighting of the new abattoirs.

Russia.—August 13th. Tenders are being invited by the Municipal Authorities of Odessa, for the electric lighting of a portion of the suburbs of the town and also of the new prison.

Southampton.—August 10th. For the construction and erection of four electric cranes and accessories, and also for alterations to gantry of an existing crane, on the Town Quay, Southampton, for the Southampton Harbour Board. Specification, with two general drawings attached, may be obtained on and after 20th, inst. from Mr. A. H. Skelton, clerk, Town Quay, Southampton, upon payment of £3 3s., which will not be returned. Further details from Mr. J. G. W. Aldridge, 9, Victoria Street, Westminster, S.W.

Spain.—The Municipal Authorities of Arevalo (Avila province) are at present inviting tenders for the electric lighting of the public streets of the town under a 20 years' concession. Tenders to be sent to El Ayuntamiento de Arevalo (Avila).

Spain.—Tenders are at present being invited by the Municipal Authorities of Estepa (Seville province), for the concession for the electric lighting of the town during a period of ten years. Tenders to be sent to El Secretario del Ayuntamiento de Estepa (Seville).

Spain.—The Municipal Authorities of Nava del Rey are inviting tenders until August 29th, for the concession for the electric lighting of the town during a period of 20 years. Tenders to be sent to El Secretario del Ayuntamiento de Nava del Rey.

CLOSED.

Bray.—For building the chimney for the electric light works extension, the tender of Mr. W. Beckett of Dublin at £546 has been accepted.

Edinburgh.—The Council has agreed to accept the estimate of Mr. John Lownie, Gilmore Park, for works in connection with additions and alterations to the central electric lighting station, amounting to £4,397.

NOTES.

Personal.—Last year about this time we recorded the fact that Mr. H. L. Mills had taken the silver medal and first place in the kingdom in the *Ordinary* grade examination, electrical engineering (City and Guilds). In October of last year Mr. Mills joined the staff of the electric lighting department of the Islington Vestry, and has just recently been appointed inspector of mains. This year he has taken the first place in the kingdom, and silver medal in *Honours*, electrical engineering (section A, City and Guilds). We believe that this double success is rather unique especially as in the latter case the result was attained by private study solely, and regard it as a sign that there is little fault to be found with the papers set. It is only fitting that men engaged in practical work of a responsible character should be the winners of the first place rather than academicals, as to be of any real service the *technical* examinations of the City and Guilds department must be what they profess to be, and not merely serve as the happy hunting ground for leisured students at polytechnics and the smaller technical colleges.

The Future of Power Development.—An article appears in *Cassier's Magazine* on this subject by Geo. S. Strong. We were just on the point of writing from the pen of Geo. S. Strong, but we happened to recollect Mr. Strong's idiosyncrasies in the literary direction, and must perforce of these same be content to say that his name appears above the article. And, after all, he really may have had something to do with its composition for it reads strangely enough, and as though *Cassier's* editor had found the editing thereof somewhat embarrassing. He begins by a statement not in accordance with fact—to the effect that the utilisation of Niagara has not provided electricity as cheaply as it can be had at the coalfields. The editor reminds him that the aluminium and carborundum industries find that they can buy energy at Niagara for a third of what it cost them at Pittsburg. Yet the cost of coal was only 30 pence per ton at Pittsburg. So much for the accuracy of our author. He next claims for the steam locomotive a consumption of less than 2 lbs. of good coal per H.P. hour., and from this bold statement he piles up a case against electrical working of railways. Without claiming anything so favourable as Mr. Baxter claims for electricity, we can assuredly say that the figures presented by Mr. Strong are unworthy of further consideration. Are we to suppose that he has, so to speak, another locomotive up his sleeve that he is so pressingly assiduous in his references to grate area, wide fire boxes, a perfectly even drawbar pull, and a boiler constructed to burn all the gases and throw no sparks? Mr. Strong has been reading about gas driven tramcars. He figuratively goes nap on gas, and states that with one charge of gas a tramcar will run 750 miles at a cost below one-third that of electric driving, and so he goes on muddling up good suggestions, picked up from various sources, and tilting into a pile with a great deal of cinder.

Röntgen Rays in Medical Research.—There was, on Tuesday, at the New Animals Institute, Kinnerton Street, Belgrave Square, a private view of some exhibits for a competition in improvements in the Röntgen X rays to aid in the diagnosis of lameness and disease in the human subject or the lower animals. The Institute is at present offering gold medals for the best photographs of the internal frame that assist in the diagnosis of disease, and the competitors include medical men, scientific institutions, and also photographers. A good number of photographs of diseased parts has been collected, but the competition will remain open for some time longer. The fifth quinquennial gathering of the International Homœopathic Medical Congress is being held this week in London. On the opening night, Dr. Gerard Smith gave a display of Röntgen photography and other novelties.

Institution of Junior Engineers.—The summer meeting of this Institution commences on Friday next, August 14th, when members will leave London and other parts for Scotland. During the week's stay there, a number of places of engineering interest will be visited, including Edinburgh electric lighting station, the instrument factories of Mr. J. White at Glasgow, and Messrs. Mavor & Coulson's electrical engineering works at Glasgow; also the Glasgow electric lighting station. On Friday, August 21st, the Institution's summer dinner will be held at the Alexandra Hotel, Glasgow, the President, Mr. Archibald Denny, presiding, and Lord Kelvin the guest of the evening.

Gas Accident.—Patrick Walker, a Govan labourer, went searching on 31st ult. for an escape of gas with a lighted candle, and in consequence was severely burned.

Niagara.—By special invitation of the Mayor of Gravesend, Mr. T. Commerford Martin, who recently lectured before the Royal Institution on "The Utilisation of Niagara," repeated the lecture at the Town Hall, Gravesend, on 28th ult.

Electrical Trade in Japan.—In an editorial, last week, *Engineering* dealt with the "Electrical Developments in Japan." Our contemporary states that the Japanese have not been slow in adopting the various applications of electricity. Electric tramways are, as we have already stated, to be laid down at Tokyo, the scheme being supported by wealthy and influential men. In view of this, and other electrical developments, we understand that the Minister of State for Communications has found it necessary to issue regulations for the control of the arrangements connected therewith. These regulations, we are told, number 111 in all, and of course deal more particularly with the various details in electric lighting and electric railway and tramway plants. From this and other information which has lately come to hand, it would seem that there is a big electrical business to be built up in Japan almost immediately, and British contractors should keep their eyes open. While referring to this subject, we would print the following paragraph from the *Daily News* of Friday last. It is somewhat unpleasant reading for us, but it should be well digested in this country:—

> At the last meeting of the Berlin Japano-German Society, Major Hidemaro, who is in Germany continuing his studies in the Berlin Military Telegraphic School, said that the camp-telegraph apparatus purchased by the Japanese in Berlin had proved far better than that from France and England, hitherto used in Japan, and that in future the Berlin material will be imported to Japan for the use of the Japanese army.

Obituary.—On Saturday last, the death of Sir William Robert Grove occurred at his residence in Harley Street, at the advanced age of 85 years. Sir William was formerly a Judge of the High Court, but he also gave considerable attention to scientific matters, particularly the study of electricity. He was the inventor in the year 1839 of the battery which bears his name, and also made other discoveries in electricity. He was awarded in 1847 the medal of the Royal Society for his Bakerian lecture on "Voltaic Ignition and the Decomposition of Water into its Constituent Gases by Heat." He was a Fellow of the Royal Society, and as a member of the Council, took an active part in the business of that Society, especially in effecting the reform of its constitution in 1847. He was president of the British Association at Nottingham in 1866, and also acted as one of the Royal Commissioners on Patent Laws. His loss is deeply regretted.

Erratum.—Traction Diagrams.—The figures given in paragraph 7, p. 130, do not agree with fig. 7, p. 130, because part of the areas subtracted project outside the rectangles, A B O N and D C P Q and, therefore, should not be subtracted. The amount of the error is very small; its effect is to increase the value of the mean added drawbar pull due to acceleration from 3·4 to 3·5 lbs. per ton.

Parliamentary Bills.—In the Commons, on Saturday, the Locomotives on Highways Bill was read a third time, and the Telegraph Money Bill passed through Committee. On Monday, in the Lords, the Light Railways Bill was read a second time, while in the Commons the Lords' amendments to the Baker Street and Waterloo Railway Bill, and the Kidderminster and Stourport Electric Tramway Bill, were agreed to.

Appointment Vacant.—As will be seen from our "Official Notices," there is a vacancy at the City and Guilds Central Technical College for an assistant with a good knowledge of mathematical and experimental physics, at a salary of £150 per annum. This vacancy is consequent upon Mr. W. G. Rhodes' appointment to Salford.

Personal.—Sir Donald Currie has started with a small party of friends on a short cruise among the Scottish islands in his new steamship, *Dunvegan Castle*. His guests include Lord and Lady Kelvin.

NEW COMPANIES REGISTERED.

Newton Electrical Works, Limited (48,236).—Registered July 25th with a capital of £30,000, in £10 shares, to acquire the business carried on at Taunton, Somerset, as to Newton Electrical Works, to adopt an agreement with F. M. Newton, and to carry on the business of electricians, engineers, electrical apparatus manufacturers, iron, brass, and metal founders, metal workers, &c. The subscribers are:—F. M. Newton, Barton Grange, near Taunton, gentleman, 80 shares; H. N. Hickley, Amberd, near Taunton, gentleman, nine shares; A. E. Newton, Henlade Lodge, near Taunton, gentleman, 10 shares; H. C. Sweet, Taunton, solicitor, 100 shares; A. W. Edgell, Cowley Place, Exeter, gentleman, 100 shares; L. C. H. Palairet, Dodhill, Taunton, gentleman, 250 shares; R. C. N. Palairet, Dodhill, Taunton, gentleman, 250 shares. The number of directors is not to be less than three, nor more than seven. The first are F. M. Newton, H. N. Hickley, and L. C. H. Palairet; qualification, £1,000; remuneration as the company may decide. Registered office, Newton Electrical Works, Herbert Street, Rowbarton, Taunton.

Improved Incandescent Electric Lamp Syndicate Limited (48,872).—Registered on July 22nd, with a capital of £700 in £1 shares, to adopt an agreement with P. Eastick and E. Sayer, and to carry on the business of electricians, mechanical engineers, suppliers of electricity, and apparatus manufacturers. The subscribers (with one share each) are:—S. P. Eastick, 130, Fleet Street, E.C., engineer; E. Sayer, 51, Ashwood Road, Cricklewood, engineer; J. Bates, 11, Lady Somerset Road, N.W., engineer; S. C. Phillips, Underhill Road, East Dulwich, publisher; A. J. Phillips, Maysoule Road, Clapham Junction, journalist; A. E. Tighe, 41, Church Road, Richmond, S.W., clerk; C. O. Bastian, 8a, Manchester Square, W., electrical engineer. The number of directors is not to be less than three nor more than five; the first are:—S. C. Phillips, C. O. Bastain, S. P. Eastick, and E. Sayer; remuneration, — per cent. of the dividends divisible. Registered office, 130, Fleet Street, E.C.

Brockie-Pell Arc Lamp, Limited (48,876).—Registered on July 23rd, with a capital of £80,000, in £1 shares, to enter into an agreement with W. Shrimpton, The Associated Underwriters, Limited, J. Brockie and B. Pell, to manufacture, sell and supply electric arc lamps, electrical apparatus generally, and to carry on the business of electric lighting company, &c. The subscribers (with one share each) are:—J. A. Fuller, 50, Chatterton Road, Finsbury Park, N., secretary; A. T. Bucknall, 17, Alexander Road, N.W., solicitor; A. W. Lawson, 338, Romford Road, Forest Gate, clerk; E. Wyatt, 11, Highbury Crescent West, N., gentleman; A. Eldridge, 36, Spencer Street, Canonbury, N., accountant; W. H. May, 38, Cornwall Road, Brixton gentleman; E. T. Church, 41, Copleston Road, Denmark Park, S.E. The number of directors is not to be less than three, nor more than seven; the first are to be appointed by the subscribers; qualification £200; remuneration, £350 for the chairman, £300 for the vice chairman, and £250 per annum each for the others. Registered by Ashurst and Co., 17, Throgmorton Avenue, E.C.

Callender's Cable and Construction Company, Limited (48m 915).—Registered on July 24th with a capital of £100,000, in £5 shares, to acquire and take over, as a going concern, the business of contractors and manufacturers of electric cables and bitumen and waterproofing materials, carried on by Callender's Bitumen Telegraph and Waterproof Company, Limited, at Belvedere, Erith, Kent, to adopt an agreement with the said company and its liquidators, and to carry on the business of electrical engineers, electricians, engineers, contractors, manufacturers of, and dealers in railway, tramway, electric and other apparatus, mechanical and chemical engineers, &c. The subscribers (with one share each) are: G. Carr, 10, Belmont Road, Ilford, accountant; G. M. Callender, Ormiston, Erith, engineer; W. D. Reid, 25, Criffel Avenue, Streatham Hill, W.; S. C. Lambert, Kyrle Road, Clapham Common, secretary; C. W. Clarke, 94, Eversleigh Road, Lavender Hill, S.W., clerk; T. Petersen, 119, Worple Road, Wimbledon, engineer; E. Thomson, 77, St. James's Road, Upper Tooting, S.W., clerk. The number of directors is not to be less than three, nor more than seven. The first are: H. Drake, W. O. Callender, D. P. McEuen, G. A. Elliott, W. M. Mackenzie, and T. O. Callender. Qualification £500; remuneration £900 per annum, and 2½ per cent. of the net profits divisible. Registered office, 90, Cannon Street, E.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Elieson Electrical Switch, Limited (41,226).—This company's annual return has just been filed. 3,806 shares have been taken up out of a capital of £5,000 in £1 shares, and 2,500 have been issued as fully paid. The full amount has been called on 1,306 shares, and £1,301 has been paid, leaving £5 in arrears.

Electric Traction Company, Limited (40,798).—This company's annual return was filed on June 25th. The capital is £300,000 in 29,880 ordinary shares of £10 each, and 1,200 deferred shares of £1 each, the whole of which has been taken up. £2 per share has been called on the ordinary, and £1 on the deferred, and £60,960 has been received.

Richmond (Surrey) Electric Light Company, Limited (36,782).—This company's annual return was filed on May 21st. The nominal capital is £50,000, in £5 shares; 6,266 have been taken up, £5 per share has been called, £31,320 has been paid, and £10 is in arrears.

Elmore's German and Austro-Hungarian Metal Company, Limited (32,457).—This company's annual return was filed on May 23rd. The capital is £250,000, in £2 shares (of which £75,000 are ordinary and the rest preference); 62,981 ordinary and 15,121 preference have been taken up, and 25,000 ordinary have been issued as fully-paid. The full amount has been called on the others, and £106,204 has been paid; 1,682 ordinary and 48 preference have been forfeited, and £1,457 12s. 10d. paid has been paid in connection therewith.

West African Telegraph Company, Limited (21,626).—This company's annual return was filed on July 2nd; 23,109 shares have been taken up out of a capital of £400,000 in £10 shares, and £231,090 has been paid.

Electrical Purification Association, Limited (27,005).—This company's annual return was filed on May 10th. 18,326 shares have been taken out of a capital of £25,000 in £1 shares, and 5,000 have been issued as fully paid; £1 per share has been called on 13,326 shares, and £13,226 has been paid, leaving £10 in arrears.

Bournemouth and District Electric Supply Company, Limited (34,129).—This company's annual return was filed on June 20th; 5,725 shares have been taken up out of a capital of £50,000 in £5 shares, the full amount has been called, and £28,625 has been paid.

River Plate Electricity Company, Limited (28,213).—This company's annual return was filed on July 17th. The capital is £500,000, divided into 49,900 ordinary shares of £10 each, and 1,000 founders' shares of £1 each; 13,557 ordinary and 872 founders' have been taken up, and 2,400 ordinary considered as paid. The full amount has been called on the others, and £112,392 has been paid, leaving £70 unpaid.

Chatham, Rochester and District Electric Lighting Company, Limited (24,773).—This company's annual return was filed on July 22nd. The capital is £50,000 in £5 shares, and 3,890 have been taken up; 1,863 have been issued as paid; £5 per share has been called on 2,000, and £2 per share on 27; and £10,051 10s. has been paid, leaving £2 10s. in arrears.

CITY NOTES.

The Electric Construction Company, Limited.

The report of the directors to be submitted to the shareholders at the third annual general meeting of the Electric Construction Company, Limited, to be held on Thursday, August 27th, 1896, at Winchester House, 50, Old Broad Street, London, E.C., at 2.30 p.m.

"The net profit of the year, after paying interest and general expenses, providing for the full maintenance of buildings and plant, and appropriating £5,000 to depreciation account, is £16,450 9s. 11d. Adding to this amount the credit balance of £10,134 15s. 10d. from last year, the sum available for dividend is £26,585 5s. 9d., whereof the directors recommend that £2,288 0s. 5d. be applied in payment of the dividend on the preference shares on September 1st next, and £11,000 in payment of a dividend of five per cent. (free of income tax) on the ordinary shares, one-half on September 1st next, and the other half on March 1st, 1897, and that the balance, £13,297 5s. 4d., be carried forward to the credit of next year. The gross manufacturing profit has increased from £31,814 12s. 7d. in 1895, to £41,353 1s. in 1896. The output of the works shows a considerable increase on that of the previous year, and the company's high reputation for excellence in design and quality of workmanship has been fully maintained. The factories are now full of orders at fairly remunerative prices. To meet the demands of the growing business a considerable addition has been made to the buildings and plant at Bushbury, and these extensions, recently completed, will not only facilitate prompt execution of orders, but also tend to economy in production. Among the more important works completed during the year, or now in progress, may be mentioned orders from the War Office and Crown agents for the colonics, and plant for various central stations, including Shoreditch, Clerkenwell, Leyton, Durban, and the Hartlepools Electric Tramways. The directors who retire by rotation at the general meeting are Sir Henry Mance and Mr. Philip Edward Beachcroft. They are eligible for re-election. Messrs. James Meston and Co., the auditors for the past year, offer themselves for re-election.

Central London Railway Company, Limited.

The report of the Central London Railway Company for the half-year ending June 30th, to be submitted to the ordinary general meeting to be held in London on August 11th, states that the expenditure amounted to £273,813, which, added to the amount previously expended, makes a total outlay of £442,098. The further payments for property and works required during the next few months have rendered a call necessary, and accordingly a call of £2 per share, payable on September 1st next, has been made. Representations have from time to time been made to the effect that it would be a convenience to proprietors desiring to do so, if they could be allowed to pay up in full the uncalled capital on their shares in advance of calls, and the directors have decided, until further notice, to accept such payments in advance, and the necessary form of application can be obtained from the secretary. The engineers report that satisfactory progress has been made with the works. The contractors have now obtained possession of station sites at Shepherd's Bush, Holland Park, Notting Hill Gate, Westbourne, Marble Arch, Oxford Circus, Tottenham Court Road, British Museum, and Chancery Lane. It has been considered expedient to enlarge the Post Office station in

Newgate Street, and there will consequently be some delay in acquiring the additional property which will be required for that purpose. The Great Eastern Company has approved the plans prepared by the engineers for the station at Liverpool Street, and it is hoped that an agreement satisfactory to all parties may soon be completed. The North London Company has also approved plans providing for a public access from Broad Street station to the Liverpool Street Station of the Central London Company, and an agreement is in course of preparation in connection therewith. The resolutions for the division, if thought fit, of the shares into "preferred half-shares" and "deferred half-shares," which will be submitted at an extraordinary general meeting to be held at the conclusion of the half-yearly meeting, are set out in the notice convening the meeting. The rate of interest payable on the capital from time to time paid up will not be affected by the proposed division, if adopted, so long as the line is in course of construction. The interest will remain during that time at the rate of 3 per cent. per annum, in accordance with the provisions of the Act of Parliament. The preference dividend of 4 per cent. proposed to be assigned to the "preferred half-shares" will not come into force until the railway is completed and opened for traffic. The following is the clause in the Central London Act, 1891, relating to the division of shares:—"Subject to the provisions of this Act the company, with the authority of three-fourths of the votes of the shareholders present in person, or by proxy, at a general meeting of the company especially convened for the purpose, may from time to time divide any share in their capital into half-shares, of which one shall be called 'preferred half-share,' and the other shall be called 'deferred half-share,' but the company shall not so divide any share under the authority of this Act unless and until not less than 60 per cent. upon such share has been paid up, and upon every such division 50 per cent. upon the entire share shall be carried to the credit of the deferred half-share (being the whole amount payable thereon), and the residue to the credit of the preferred half-share."

Edison & Swan United Electric Light Company, Limited.

The ordinary general meeting of this company was held at the Cannon Street Hotel on Friday last. Mr. James Staats Forbes presided, and said that it was necessary for him to be reticent regarding the business, for if he gave them a great variety of details they would be only arming their opponents. Their business was progressing in bulk, although, under the necessity of competition, there was a diminution in the profit on many things. The year's working had given them a credit balance of £27,526, and, after providing the interest on the debentures—the price of the purchase of the Swan residuum—there was enough money to pay 5 per cent. on the "A" capital, and to carry forward a considerable balance. They could pay a larger dividend than 5 per cent., only they did not think it would be prudent to do so in existing circumstances. They thought that 5 per cent. would be a very good dividend to maintain until they saw that they could safely pay more. As he had said, the competition was severe, although it was a little less serious now. The Edison and Swan lamp had a certain reputation, and a great many were committed to use it and liked it. A good many who had been induced to try other lamps had given them up and were coming back to this company, but there was still competition as to prices. Nevertheless, the bulk of their business had increased, but the cost of materials had rather gone against them. They also had a strike in the early part of the year, which disarranged their affairs for some time. The strike opened their eyes to methods of making themselves independent of the class of persons who struck; but the company suffered during the strike, and for some time afterwards. This had necessarily somewhat adversely affected the results of the year's working. The sale of lamps, fittings, royalty on holders, &c., had amounted on the past year to £128,101, which exceeded by about £14,000 the amount obtained in the previous year. The profit, however, was about £2,000 less. They were now in a much sounder position than they had ever been in before, and they believed that the company might be made more prosperous in the future. The stock on hand on July 1st, 1895, was £95,983; but by dint of working on it, eliminating bad parts of it, and sales, they had managed to reduce the amount, and on June 30th last the stock amounted to £93,707. That was its estimated value after a great deal of revision, and some considerable writings-down. He hoped that sooner or later they would be able to give the "B" shareholders some return.

Mr. J. W. Swan seconded the motion, which was carried unanimously.

The Electrical Development and Finance Corporation, Limited.

The object of this company, with a capital of £500,000, half of which is now offered for public subscription, is fully explained in our advertisement columns. Business operations are to be at once commenced on electric traction, lighting, alternating current motors, and transmission of power in South Africa. From these four subjects, "and other likely opportunities for the employment of capital, there appears every prospect of success for the Corporation."

Another company, formed in 1890, whose business has been practically carried on on the lines now proposed, is quoted as a criterion of the Corporation's chances of succeeding, but we believe that company, whose identity will readily present itself to the reader, had only to pay dividend on capital of £20,000. 20 per cent. on that amount is more easily secured than 2 per cent. on a quarter of a million.

The consulting engineer, whose remuneration depends on profits only, is now known in connection with electric lighting, but we are not aware that he has had any special experience to enable him to advise the board on electric traction, alternating current motors and the transmission of power in mining districts.

There is no promotion money to be squandered, the only expenses being a 2 per cent. commission upon the capital, which covers all preliminaries, including registration fees, down to the first allotment of shares. We cannot say that the prospectus is attractive, but with Mr. Claude Johnson on the board of directors, provided he can find sufficient time to look after their interests, investors may have the satisfaction of knowing the business is in safe hands.

We, who know the requirements of the times, and who also know the man who will be responsible for the guidance of this company, probably would be more sanguine of its future, if formed, than will the investing public, who, we fear, will be too much inclined to take the prospectus at its full value.

Waterloo and City Railway Company, Limited.

The fifth half-yearly general meeting of the shareholders of the Waterloo and City Railway Company was held on Thursday at Waterloo Station, Mr. W. S. Portal presiding.

The Chairman, in moving the adoption of the report, said the directors had to record continuous and steady progress. The engineers had prepared him a short summary of the progress of the work up to date, which was very instructive and very interesting. As they knew, the plan adopted was to erect a staging in the middle of the Thames above Blackfriars Bridge, where two large shafts were sunk 42 feet below the bed of the river. At the bottom of those shafts four shields were erected—two in each shaft, and the driving of tunnels, 12 feet in diameter, was commenced—two towards the City and two towards Waterloo. At the date of the last general meeting the City tunnels were in Queen Victoria Street, nearly opposite St. Nicholas Church. They had now reached the western end of the City Station, where two tunnels, 23 feet in diameter, had to be constructed, to give the necessary space for the up and down platforms. Towards Waterloo the progress had not been quite so rapid, because for some months they had been passing through gravel, which had made the work more difficult. The northernmost or up tunnel was now within ten yards of the South-Eastern viaduct, and in the course of a very few days the shield which was lowered in the Thames at Blackfriars would see daylight at Waterloo. The southernmost or down Waterloo tunnel had now reached a point in Stamford Street on the Waterloo side of Cornwall Road. The total length of single tunnel constructed during the last six months had been 1,100 yards. It was very satisfactory to know that a work of such magnitude and importance had been carried out without any interference with the traffic in the streets—the contractors' yard having been a staging in the middle of the Thames, all the materials having been delivered by barges. The works at Waterloo Station, which were of considerable magnitude and great difficulty, were let to Messrs. Perry & Co. They passed close under the general offices of the company, and below several of the piers supporting the arches over which Waterloo Station was built. The work had made very good progress, and the water in the foundations was very much less than it was when the work was commenced. One night watchman had lost his life by falling into a shaft, but with that exception the works in connection with the railway had been carried out without any mishap. Arrangements had been made with the London and South Western Railway with regard to the terminus under Waterloo Station. Terms had been settled on the basis of a rent or easement, instead of a capital payment, which would secure them the accommodation necessary for their purpose. They had also made arrangements with the City and South London Railway to use their central station at the Mansion House on advantageous terms. In conclusion, the chairman said he was sure the proprietors would allow him to offer their congratulations to the engineers—Mr. Galbraith and Mr. Greathead—upon the progress they had made and the success that had so far attended their efforts, and to express a hope that the same success would attend them until the railway was completed.

The Hon. H. W. Campbell seconded the motion, and the report was adopted.

Unbreakable Pulley and Mill Gearing Company, Limited.—This company has paid a dividend of 10 per cent., and carried forward and reserved considerable amounts as usual.

Cuba Submarine Telegraph Company, Limited. The directors recommend a dividend on the ordinary shares at the rate of 8 per cent. per annum, tax free, for the half-year ended June 30th.

Brockie-Pell Arc Lamp Company, Limited.—The letters of allotment and regret were posted on Tuesday evening.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending August 2nd, 1896, were £1,036; week ending August 4th, 1895, £804; increase, £232; total receipts for half-year, 1896, £4,524; corresponding period, 1895, £4,224; increase, £300.

The Direct Spanish Telegraph Company. The estimated receipts for the month of July, 1896, were £1,950.

The Liverpool Overhead Railway Company. The receipts for the week ending August 2nd, 1896, amounted to £1,357; corresponding week last year, £1,355; increase, £2.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending July 31st, 1896, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brasilian Telegraph Company, Limited were £2,608.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation, July 29th.	Closing Quotation, Aug. 5th.	Business done during week ended Aug. 5th, 1896. Highest.	Lowest
173,400£	African Direct Teleg., Ltd., 4 % Deb.	100	4 %	4 %	4 %	100 —104	100 —104	...	...
25,000	Amazon Telegraph, Limited, shares...	10	...	...	...	8½ — 9½	8½ — 9½	...	...
1,012,880£	Anglo-American Teleg., Ltd.	Stock	£2 11s.	£2 2s.	£2 9s.	50 — 52	52 — 54	53¼	52
2,993,560£	Do. do. 6 % Pref.	Stock	£5 2s.	£4 4s.	£4 18s.	96½ — 97½	97½ — 98½	98¼	97
2,993,560£	Do. do. Defd.	Stock	...	...	...	9 — 9½	9 — 9½	9⅜	...
130,000	Brazilian Submarine Teleg., Ltd.	10	6½% §	7 %	...	15¼ — 15⅝	15¼ — 15⅝	15⅝	...
75,000£	Do. do. 5 %, Debs., 2nd series, 1906	100	5 %	5 %	5 %	112 —116	112 —116	115¼	...
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	... §	2½%	4 %	3¼ — 4	3¼ — 4	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	160 —170	160 —170	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	2 % §	1½%	1½%	1/16 — 3/16	1/16 — 3/16xd	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	12½ — 13½	12½ — 13½	13 3/16	13
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	20 — 21	20 — 21	...	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	3½ — 4½	3½ — 4½	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 10½	10 — 10½	...	...
30,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000 ...	50	...	4½%	4½%	107 —110%	107 —110 %	...	..
60,710	Direct United States Cable, Ltd.	20	2⅝% §	2 %	2½%	9⅜ — 10¼	9⅜ — 10¼	10	9⅜
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½% §	6½%	6½%	17⅜ — 18¼	17⅜ — 18¼	18 3/16	17 13/16
70,000	Do. 6 % Cum. Pref.	10	6 % §	6 %	6	18½ — 19	18½ — 19½	19	18⅜
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	5 %	106 —109	104 —107 xd	...	
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	4 %	131 —134	131 —134	133	132
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	7 %	17⅜ — 18¼	18 — 18½	18⅜	18
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5 %	100 —104	100 —104	...	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5 %	101 —104	101 —104	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4 %	132 —135	130 —133 xd	...	...
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5 %	100 —104	100 —104	...	...
107,600£	Do. do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5 %	101 —104	101 —104	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4 %	106 —109	105 —108 xd	...	...
200,000£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4 %	111 —114 %	111 —114 %	...	..
180,227	Globe Telegraph and Trust, Ltd.	10	4⅜% §	4½%	4½%	11¼ — 11⅜	11¼ — 11⅜	11 9/16	11⅜
180,042	Do. do. 6 % Pref.	10	6 % §	6 %	6 %	17⅜ — 18¼	17⅜ — 18¼	18⅛	17⅜
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜%	8⅜%	10 %	23½ — 24½	23½ — 24½	24	...
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	105 —108	105 —108	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10 %	53 — 56	53 — 56	54	...
100,000£	London Platino-Brasilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6 %	111 —114	111 —114	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000... ...	5	4 %	4 %	...	2 — 2½	2 — 2½	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 % §	5 %	5½%	7⅝ — 7⅞	7⅞ — 8	7⅞	7 11/16
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	17 — 19	17 — 19	...	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	16½ — 17½	17 — 18	17⅜	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6¾ — 7⅛	6⅞ — 7⅛	7	...
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	107 —110	107 —110	...	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	...	4½%	5 %	3/32 — 7/32	3/32 — 7/32	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4 %	108 — 111	108 —111	...	...
11,839	Reuter's Ltd.	8	0 %	*nil*	5 %	7 — 8	7 — 8	...	...
3,381	Submarine Cables Trust	Cert.	...	...	...	140 —145	140 —145	...	...
58,000	United River Plate Teleph., Ltd.	5	...	3 %	4 %	3⅜ — 4¼	3⅜ — 4¼	...	...
146,733£	Do. do. 5 % Debs.	Stock	5 %	5 %	5 %	101 —106	101 —106	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	*nil*	*nil*	4 %	5 — 6	5 — 6	...	...
238,300£	Do. do. do. 5 % Debs.	100	5 %	5 %	5 %	104 —107	104 —107	...	...
30,000	West Coast of America Teleg., Ltd.	10	*nil*	*nil*	*nil*	1 — 2	1 — 2	...	...
150,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	8 %	99 —104	99 — 104	...	...
64,248	Western and Brazilian Teleg., Ltd.	15	2½%	3 %	3 %	8⅜ — 9½	8⅜ — 9½	...	...
33,129	Do. do. do. 5 % Pref. Ord. ...	7½	5 %	5 %	5 %	7 — 7½	7 — 7½	...	...
33,129	Do. do. do. Def. Ord.	7½	...	1 %	1 %	2¼ — 2⅝	2¼ — 2⅝	...	...
165,200£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	6 %	105 —109	103 —107 xd	...	...
206,400£	Do. do. do. do "B," do.	100	6 %	6 %	6 %	105 —109	103 —107 xd	...	...
88,321	West India and Panama Teleg., Ltd.	10	⅜%	⅜%	⅜%	1⅛ — 1⅜	1⅛ — 1⅜	1 5/16	...
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	11½ — 12	11½ — 12	11½	...
4,669	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	9½ — 10½	9½ — 10½	10 3/16	...
80,000£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	5 %	108 —111	108 —111	...	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7 %	110 —115	110 —115	...	...
164,300£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6 %	104 —107	104 —107	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	4½%	4½%	5 %	8¼ — 8⅜	8¼ — 8⅜	8⅜	8 3/16
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	5 %	5 %	5 %	7⅞ — 8¼	7⅞ — 8¼	8⅛	...
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	...	4½%	114 —116	114 —116	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	...	5 %	5 %	14¼ — 15½	15 — 16	15⅝	15¼
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	16½ — 17½	16½ — 17xd	17	...
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	133 —137	133 —137	...	...
22,475	County of London and Brush Prov. Elec. Ligtg., Ltd., Ord. 1—22,475	10	...	...	*nil*	8 — 9	8 — 9	8⅞	...
20,000	Do. do. do. 6% Pref., 40,001—50,000	10	...	...	6 %	13½ — 14	13½ — 14	14	13⅞
10,000	Do. do. do. iss. at 2 pm., £1 paid ...	10	...	...	...	4½ — 5½	3½ — 4½	4	...
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000	10	2½%	3 %	4 %	13¼ — 13⅝	13½ — 13⅝	13⅝	13⅜
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	4½%	119 —123	119 —123	...	...
6,452	Notting Hill Electric Lightg. Co., Ltd.	10	...	1 %	2 %	11 — 12	11 — 12	12	...
19,980	*St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	4½%	6½%	7½%	12 — 13	12½ — 13½xd	13	...
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	9½ — 10½	10 — 11	10½	...
50,000	Do. do. 4 % Deb. stock Red. ...	Stock	...	...	...	104 —106	104 —107	...	...
67,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	4 %	5 %	7 %	11— 12	11 — 12	11 9/16	11½

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

§ Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share ‡	Dividends for the last three years. 1893.	1894.	1895.	Closing Quotation, July 29th.	Closing Quotation Aug. 5th.	Business done during week ended Aug. 5th, 1896. Highest.	Lowest
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000...	S	5 %	2½%	...	1 — 1¼	1 — 1¼	...	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	6 %	3 %	...	1⅜ — 1⅝	1¼ — 1½	1 7/16	...
125,000	Do. do. 4½ % Perp. Deb. Stock.... ...	Stock	4½%	4½%	...	112 —115	112 —115	113½	113
76,770	Do. do. 4½% 2nd Deb. Stock Red. ...	Stock	...	...	...	98 — 102	98 —102	98	...
9,104	Central London Railway, Ord. Shares	10	...	...	...	10½ — 11	10½—11	10 13/16	...
207,649	Do. do. do. £2 paid	10	...	...	...	2¼ — 2½	2¼ — 2½	2⅝	2 5/16
630,000	City and South London Railway	Stock	1½%	1½%	1 5/16%	45 — 47	45 — 47	46¾	46
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	3 %	*nil*	*nil*	2 — 2½	2 — 2½	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	7 %	5 %	5 %	1⅞ — 2¼	1⅞ — 2¼	...	...
17,139	Do. do. do. "A" Shares 01—017,139	5	7 %	5 %	5 %	3 — 4	3 — 4	...	...
100,000	Do. do. do. 4½% Deb. Stock Red. ...	Stock	...	4½%	4½%	103 —106	103 —106	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	*nil*	5 %	1⅜ — 1⅝	1¼ — 1⅜	1 13/16	1⅜
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	7 %	2½ — 3	2½ — 3	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	*nil*	...	⅝ — ¾	⅝ — ¾	...	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	*nil*	...	⅝ — ⅝	⅝ — ⅝	...	...
9,600	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	*nil*	*nil*	10½%	10½ — 11½	10½ — 11½	...	...
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	5 %	6 %	8 %	17½ — 18½	17½ — 18½	18¼	...
3,000	Do. do. do. 7% Pref.	10	7 %	7 %	7 %	17½ — 18½	17½ — 18½	...	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	...	4½%	109 —114	109 —114	...	...
50,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	12½%	10 %	10 %	22 — 23	22 — 23	22¾	...
300,000	Do. do. do. 4 % 1st Mort. Debs.	100	...	...	...	106 —109	106 —109	108¾	107½
37,500	Liverpool Overhead Railway, Ord.	10	1 %	1½%	2½%	3⅜ — 13⅞	13⅜ — 13⅞	...	...
10,000	Do. do. Pref., £10 paid	10	5 %	5 %	5 %	17½ — 17⅜	17½ — 17⅜	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	20 %	15 %	39 — 42	39 — 42	40½	39½
150,000	Do. do. do. 5 % Bonds, red. 1899	100	5 %	5 %	5 %	102 —105	102 —105	...	...
54,000	Waterloo and City Railway, Nos. 1 to 54,000. £6 paid ...	10	...	...	...	8 — 8½	8 — 8½	8¼	...

† Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50% for 1890.

Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7%; 1890—5%

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 6 –6½

Electric Construction Corporation, 6 % Debentures, 103—106.

House-to-House Company (£5 paid), 4—4½.

Do. do. 7 % Preference, of £5, 8½—9.

Do. do. 4½% Debentures of £100, 109 - 111.

Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 9½—10xd; 1st Preference Cumulative 6 %, £5 (fully paid), 7½—8xd.

London Electric Supply Corporation, £5 Ordinary, 1—1½.

Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 7¼—7¾.

Bank rate of discount 2 per cent. (February 22nd, 1894).

ALTERNATE CURRENT TRANSFORMERS.

By Dr. J. A. FLEMING, F.R.S.

Society of Arts Cantor Lectures. Lecture III., delivered February 19th, 1896.

(*Continued from page* 157.)

The Testing of Transformers.

Having considered the action and construction of transformers, our next duty is to notice the principal facts connected with the testing of transformers. This is a matter of considerable importance. It is not too much to say that in very few alternating current stations is there any proper system of purchasing transformers to a rigid specification, and enforcing delivery to this specification by efficient methods of electrical testing. Engineers appear to be far too often quite content to accept manufacturers' figures without any confirmation. As an instance of the possible consequences of such a course, I may mention that not long ago I had occasion to specify for two transformers on behalf of a corporation, the core loss of these transformers was to be not greater than 550 watts when measured at the proper primary pressure, and on open secondary circuit. When the transformers were delivered they were tested. One of them was found to comply with the specification, the other took up 1,090 watts under the same circumstances. As these transformers were 30-kilowatt transformers, intended to be worked in a sub-station, and to be connected with the mains for at least 4,000 hours in the year, it is perfectly clear that if no test had been applied, and if the transformers had both been accepted, one of these transformers would have taken up 500 watts more than the other. This additional core loss, proceeding for 4,000 hours in the year, would have meant an addition to the magnetising losses of 2,000 Board of Trade units per annum. As this would have involved an expenditure in coal and water of at least one penny per unit, the facts, translated into money, mean that one transformer would have cost something like £8 per annum more than the other to maintain magnetised. If this is capitalised at only 3 per cent. it means £240, whereas the actual cost of the transformers did not exceed £140 each. It is clear, therefore, that the omission of a systematic process of testing transformers and of specifying for them for test may involve a Supply Company or Corporation in an increased annual expenditure for maintenance, which under some circumstances may even amount to a considerable sum. In dealing briefly with the subject of testing transformers I shall not attempt to describe all the many different methods which have been suggested, but confine myself shortly to one which is simple, direct, and can be applied in any sub-station or workshop. It should always be remembered that although an electrical method may theoretically give the required result, yet practically it may be difficult to get good results with it on account of the fact that to obtain the necessary accuracy we must assume an unattainable precision in some of the measurements. The method which, after long experience in this matter, I have found most applicable in all ordinary cases is one depending on the employment of a properly constructed wattmeter, standard power absorbing resistance, and an auxiliary transformer. We will discuss, in the first place, the construction of each of these instruments separately. If an alternating current is sent through a fixed coil of wire, and another current through a movable coil suspended with its magnetic axis at right angles to the first coil, the centres of the coils being co-incident, then in general we find an electrodynamic force tending to turn the movable coil from one position to another. If the initial position of the coils is with their magnetic axes at right angles, then the passage of the current tends to displace the magnetic axes so as to make them co-incident. If a couple or torque is applied to the movable coil to bring it back to its original position, either by means of a spiral spring or a torsion wire, it can be shown that the couple required to hold the coils in their initial position, with magnetic axes at right angles to one another, is proportional to the mean value of the product of the instantaneous values of the two periodic currents passing through the two coils taken at equi-distant intervals throughout one complete period. This mean product is, therefore, at once measured in terms of a mechanical couple. Such an arrangement is called an electro-dynamometer. If the current through one of these coils is the current being supplied to an inductive circuit, say a transformer, and if the current through the other circuit, say the movable circuit, can be made to be proportional to the potential difference between the extremities of the inductive circuit, then the dynamometer, now called a wattmeter, will give us, when used as above described, the true mean value of the product of the instantaneous values of the current through the inductive circuit, and its terminal potential difference taken at equidistant intervals throughout the phase; this mean product is a measure of the mean power being taken up at that instant in the inductive circuit, and hence we are able by one measurement to measure this power. In order that good results may be obtained with a wattmeter constructed as above described when employing alternating currents, there are certain precautions which must be observed, but which instrument makers almost habitually disregard. In the first place, the wattmeter must be constructed entirely of non-conducting material. There must be no metal, either iron or brass, in or near the fixed or movable coils. The reason for this is, that if metal is placed in this position, the alternating currents circulating in the fixed or movable coils set up eddy currents in this metal,

and these eddy currents re-act upon the movable coil, and cause a displacement which creates a false reading. In the next place, in order to make the instrument direct reading, it is essential that the fixed coil should be constructed in two parts, which are capable of being moved to or from one another, so as to strengthen or weaken the field in the place where the movable coil hangs. In this manner the wattmeter can be adjusted, so that a certain angular deflection of the torsion head of the instrument, creating a certain definite couple acting on the movable coil, can be made to mean a certain definite amount of mean power passing through the instrument. Thirdly, precautions must be taken to prevent the effect of the currents in the wires bringing the currents to or from the wattmeter affecting the movable coil. For this purpose these leads ought to be constructed of concentric cable, and the wattmeter carefully tested, before employment, to find out if this cause of error exists. In the next place we require a non-inductive resistance to act as a standard power-absorber. This can best be made by employing the cages as described in the first lecture. A series of these inductionless resistances, say 20 of them, each capable of withstanding a pressure of 100 volts, are joined up in series, and well insulated. Under these circumstances, a pressure of 2,000 volts can be placed on the extremities of this resistance,

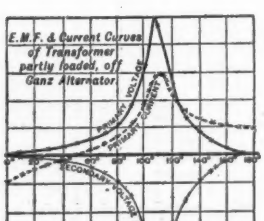

E.M.F. & Current Curves of Transformer partly loaded, off Ganz Alternator.
PRIMARY VOLTAGE
PRIMARY CURRENT
SECONDARY VOLTAGE AND CURRENT

FIG. 34.

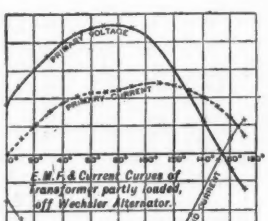

PRIMARY VOLTAGE
PRIMARY CURRENT
E.M.F. & Current Curves of transformer partly loaded, off Wechsler Alternator.
SECONDARY VOLTAGE AND CURRENT

FIG. 35.

and a certain current will flow through it. This current can be measured by a sensitive dynamometer, which has previously been calibrated in the usual way. The potential difference between the extremities of the non-inductive resistance when employed on a high-tension circuit is best measured by means of an electrostatic voltmeter. Then, lastly, we require an auxiliary transformer for the following purpose. It has been explained in Lecture I. that when a transformer of the closed iron circuit type is worked on a constant potential primary circuit, the secondary electromotive force set up in the secondary circuit is exactly opposite in phase to the primary electromotive force. This is further illustrated by the curves in figs. 34, 35, 36 and 37, which show the primary and secondary E.M.F. curves of a Ganz, a Wechsler, and a Westinghouse transformer in various conditions of load, and it will be seen that the primary and secondary E.M.F. curves are in step with one another, but opposite in phase. If, therefore, a transformer has its secondary circuit closed through a non-inductive resistance, the secondary current will always be exactly opposite in phase, but proportional in magnitude to the potential dif-

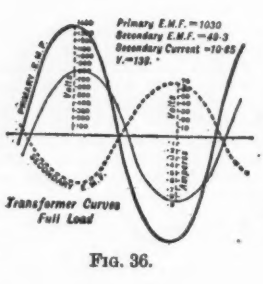


FIG. 36.

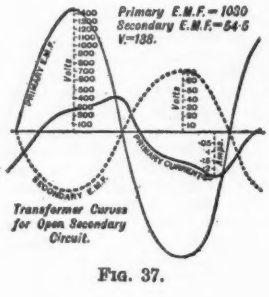


FIG. 37.

ference between the primary terminals of the transformer. In order, then, to make a measurement of the efficiency of any transformer, this apparatus is arranged as in fig. 38, the transformer to be tested is denoted by the lines over the words "Transformer under test." The wattmeter has its fixed coils connected in series with the primary circuit of the transformer to be tested, and its movable coil is connected in series with the secondary circuit of the transformer, which is called the auxiliary or *wattmeter transformer*, and by including a few incandescent lamps, L, in the secondary circuit of this auxiliary transformer, the proper current can be given to the movable coil of the wattmeter. The primary circuit of the auxiliary transformer is connected to the same two mains as the primary circuit of the transformer to be tested, and an electrostatic voltmeter, V, is joined across the primary terminals of the transformer to be tested. The standard inductionless resistance just described is also placed across the primary terminals of the transformer to be tested, and a two-way high tension switch is arranged so as to throw on the resistance, or the primary circuit of the transformer under test at pleasure. A dynamometer is connected in series with this standard resistance, to measure the current passing through it. The process of measuring the power supplied to the transformer under test is then as follows:—In the first place we connect to the wattmeter the standard power of absorbing resistance, and observe the current flowing through it, and the potential difference between its extremities. The product of these two numbers in amperes and volts gives us the mean power in watts taken up in the standard resistance. At the same instant a reading of the wattmeter is taken; that is to say, an observation of the amount of torsion required to be given to the wire or spring holding the movable coil to bring it back into its normal position. Let this reading be D_1, and let the power taken up in the standard resistance in watts be represented by W_1. In the next place, the standard resistance is switched off, and the transformer under test is switched on to the wattmeter, and another reading is taken of the wattmeter. Let this reading be D_2. The true power being taken up in this transformer under test is given by the value of the expression $\frac{D_2}{D_1} \times W_1$.

In this manner the wattmeter is employed as a kind of electrical steelyard, to weigh or measure the ratio between the known power taken up in the standard resistance and the unknown power taken up in the transformer. A measurement can thus be made with extreme accuracy, either in a central station, a transformer sub-station, or a private house. All that it is necessary to do is to connect the wattmeter, in the manner described, in place of one of the primary fuses; that is, to place the series coil of the wattmeter in series with the transformer under test, and then to connect up the standard resistance and the auxiliary transformer, as shown in the diagram. The iron core loss of a transformer on open secondary circuit can thus be quickly and accurately measured, and, with a properly constructed wattmeter of the kind described, there is not the slightest difficulty in making the measurement of the core loss of any required degree of accuracy.

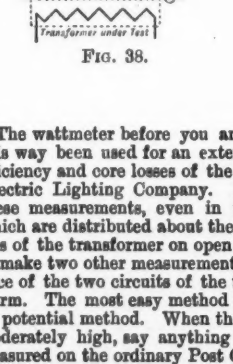


FIG. 38.

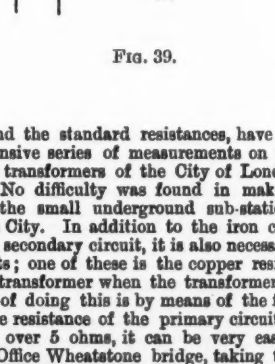


FIG. 39.

The wattmeter before you and the standard resistances, have in this way been used for an extensive series of measurements on the efficiency and core losses of the transformers of the City of London Electric Lighting Company. No difficulty was found in making these measurements, even in the small underground sub-stations which are distributed about the City. In addition to the iron core loss of the transformer on open secondary circuit, it is also necessary to make two other measurements; one of these is the copper resistance of the two circuits of the transformer when the transformer is warm. The most easy method of doing this is by means of the fall of potential method. When the resistance of the primary circuit is moderately high, say anything over 5 ohms, it can be very easily measured on the ordinary Post Office Wheatstone bridge, taking the precaution, however, to short circuit the secondary circuit, but in those cases in which the resistance of either or both circuits is very low, then it is best measured in the following manner. A suitable standard low resistance, either $\frac{1}{100}$th or $\frac{1}{10}$th of an ohm, or 1 ohm is connected in series with the transformer circuit to be measured, and a small current from a dry cell or secondary battery is sent through this circuit, appropriate resistance being added to increase the total resistance to a proper amount. A movable coil high resistance galvanometer has its terminals then connected first to the extremities of the standard low resistance, and second to the terminals of the copper circuit of the transformer which is under test. The ratio of these two deflections gives us at once the ratio of the resistance of the transformer circuit to that of the standard low resistance, and in this manner the copper resistance of each circuit of the transformer can be measured. This copper resistance, however, if measured at the ordinary temperature of the air has to be corrected to determine what it is when the transformer has reached its constant temperature. When a transformer is put to work, whether on open circuit or closed secondary circuit, it soon reaches a final temperature which ought never, under any circumstances, to be more than 100° C. In order to determine what this temperature is, one of the easiest methods is to connect the transformer on open secondary circuit for five or six hours to the high pressure circuits, and when the transformer has reached its final and constant temperature to suddenly switch it off, and quickly make a measurement of the copper resistance of the secondary circuit as above described. Then, when the transformer is quite cold, another measurement of the copper resistance may be

taken, which will be found to be much less, since the high conductivity copper employed in transformer manufacture has a temperature coefficient of about 0·4 per cent. per degree Centigrade, it is very easy to calculate from these two measurements what is the final and constant temperature of the transformer. Having then measured the copper resistances, and calculated what it will be at the final temperature of the transformer, we have next to measure the secondary drop between full and no load. For this purpose an electrostatic voltmeter is connected across the secondary circuits, and its reading taken when the primary terminal potential difference is also known: The transformer is then loaded up to its full load on its secondary side, and the primary potential difference being kept at the same amount, the secondary potential difference will be found to have fallen, and the amount of difference between its value when the transformer is fully loaded and its value when the transformer is on open circuit is called the secondary drop. It is sometimes difficult to make this measurement with great accuracy, especially when the transformers are working off commercial circuits, but it can always be done in the way shown in the diagram in fig. 39, if we possess two identical transformers, and a low reading electrostatic voltmeter. The two transformers are connected up with their primary circuits in parallel, and with their secondary circuits opposed to one another through the voltmeter. The voltmeter then reads, not secondary volts to either transformer, but the difference between the two differences. If one transformer is loaded up to full load, the voltmeter will read directly the secondary drop, and since both transformers are affected equally by any variation of the primary pressure, it does not affect their difference, and, therefore, there is no difficulty in getting the measurement with any required degree of accuracy. Having in this manner measured the iron core loss at no load, or on open secondary circuit, the copper resistances when the transformer is warm, and the secondary drop, we have all the information necessary to enable us to make a complete report on the transformer. It has been abundantly shown by experiments which were carried out by me in the year 1892,* that when a transformer is gradually loaded up, the iron core loss is constant at all loads, and that it is only the copper losses that vary. Hence, if we know the iron core loss—that is to say, the loss due to eddy currents and hysteresis in the core when the transformer is on open secondary circuit, we have only to add to this loss the copper losses in the transformer, that is, the energy losses due to the resistance of the copper circuits, in order to obtain the total power absorption in the transformer at any load. Let P_1 be the total power in watts given in a transformer on the primary circuit, and let P_2 be the total power in watts given out on the secondary circuit to some external resistances, such as lamps. Let I be the total iron losses in the transformer, and C the total copper losses, $P_1 = I + C + P_2$. Hence the difference between P_1 and P_2 is a quantity which can be calculated when we know I and know C; and the efficiency of the transformer is given by the ratio of P_2 to P_1, expressed as a percentage. The copper losses can be calculated with sufficient accuracy in the following manner:—Let us suppose that the transformer under test is a 10 kilowatt transformer, that is to say, is constructed to permit 10,000 watts being taken out from the secondary circuit, and that the secondary watts are intended to be 100. Then the transformer at full load will give out a current of 100 amperes. If we imagine the full load of the transformer to be divided into 10 parts, then when the secondary circuit is delivering 10 amperes at 100 volts the transformer is on $\frac{1}{10}$th load, when it is delivering 20 amperes at 100 volts the transformer is on $\frac{2}{10}$ths of full load, and so on. If the transformation ratio of the transformer is known, that is, the ratio between the secondary volts and the primary volts, or secondary terminal potential difference and primary terminal potential difference, when the transformer is on open secondary circuit, then the primary current can always be calculated with approximate accuracy from the secondary current by simply multiplying the secondary current by the number expressing the transformation ratio. Hence we can calculate the primary and secondary currents corresponding to each decimal fraction of full secondary load. Knowing the resistances of the two circuits of the transformer when warm, we can, therefore, calculate the copper losses in each circuit, because if R is the resistance of a circuit, and C the R.M.S. value of the current flowing through it, then C^2R is equal to the mean power wasted in that circuit. Calculating in this way the total copper losses for the two circuits corresponding to each decimal fraction of the full secondary load, we can add these values to the constant iron core loss experimentally determined, and obtain the total power lost in the transformer, corresponding to each decimal fraction of full load. We have, therefore, the difference between P_1 and P_2, corresponding to known values of P_2. Hence we can calculate the ratio of P_1 to P_2 for each decimal fraction of the full secondary load, and, therefore, we have the efficiency of the transformer and the total loss in the transformer given to us at each fraction of the full secondary load. This is by far the best method of determining the efficiency of very large transformers, because it does not necessitate loading up the transformer to its full load on an actual resistance; and even if this can be done, the measurement which we actually require is the difference between two large observed quantities, and is, therefore, very liable to be affected by an error in either of them. Having obtained in this manner the total losses in the transformer for the various decimal fractions of the full secondary load, the most convenient graphic method of representing the results is by a total loss diagram. A horizontal line is taken, and is divided into 10 equal parts representing the decimal fractions of the full secondary load. At each part a vertical line is set up, representing the total losses in the transformer, both the copper and the iron losses, and two curves are drawn, as in fig. 40, one representing the variation of the total copper losses in the transformer with the secondary load, and the other representing the constant iron loss at all loads. From this curve another curve, called the efficiency curve, can be drawn in the following manner (see fig. 41). A horizontal line is taken, representing the secondary output, and divided into 10 equal parts representing the decimal fractions of the full secondary load. At each point a vertical line is set up, representing the ratio between the power given out by the transformer to the power taken in by the

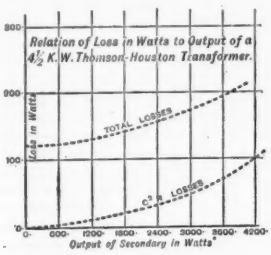


Fig. 40.

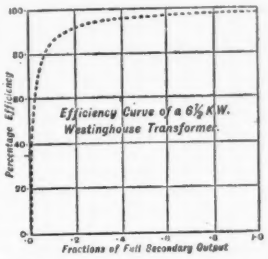


Fig. 41.

transformer, expressed as a percentage, and the curve delineated by these points gives us the efficiency curve of the transformer. In a well-designed transformer this efficiency curve is a square-shouldered curve, rising very rapidly up to 90 per cent. at one-tenth of full-load, and to 96 or 97 per cent. at full load. A fairly good estimate of the value of a transformer, from an efficiency point of view, can be obtained by taking its efficiency at one-tenth of full secondary load. Even quite small transformers are now made which have an efficiency of 80 per cent. at one-tenth of full-load. Large transformers of 30 to 50 kilowatts and upwards can be made to have an efficiency of 90 per cent. at one-tenth of full load. Ten years ago it was difficult to get any transformer having more than 40 to 50 per cent. of efficiency at one-tenth of full load.

It should be noted, however, that the form of this efficiency curve, as well as that of the current curve, depends upon the nature of the curve of primary E.M.F. The diagram in fig. 30, Lecture II., shows the difference which may exist in the efficiency curves in the case of the same transformer tested in two different alternators, a Ganz and a Wechsler.

In considering the performance of transformers, we are not only concerned with the instantaneous efficiency—that is, the efficiency under any particular load—but with what is called the all-day or all-year efficiency. This can be calculated when we know the efficiency of the transformer at various loads, and when we know the nature of the load diagram, as it is called, on which the transformer is supplied. Thus, for instance, let us make the assumption that the load diagram of a transformer is a 10 per cent. load diagram—that is to say, let us assume that out of the 24 hours, for 11 hours the transformer is giving no current from the secondary circuit, for five hours is supplying at one-tenth of its full secondary output, for four hours one-eighth, for three hours one-quarter, and for one hour three-quarters. It will be found, on adding up these outputs, that they amount to one-tenth of that which the transformer would be supplying if working at its full secondary output for the whole 24 hours. Let us take, then, the case of a 24-hour kilowatt transformer, having 1·35 per cent. loss on open secondary circuit, and 1·35 per cent. — 1·60 per cent. loss at full load. This gives an open circuit loss of 324 watts at no load; that is to say, 324 watts is the core loss in the transformer at no secondary load; the efficiency at one-tenth full load is 86 per cent., and at full load 96 per cent. From the total loss diagram it can then be shown that the transformer takes up in its primary circuit 324 watts on open secondary, 2,762 watts at one-tenth of full load, 3,372 watts at one-eighth of full load, 6,420 watts at one-fourth full load, and 18,162 at three-fourths of full load. We can then construct an energy balance-sheet for the transformer as follows, putting on one side the energy in watt-hours given by the primary circuit, and on the other side the energy in watt-hours taken from the secondary circuit, and these figures will be as follows:—

Energy in Watt-hours given to Primary Circuit.

11	×	324	=	3,564
5	×	2,762	=	13,810
4	×	3,372	=	13,488
3	×	6,420	=	19,260
1	×	18,612	=	18,612

Total = 68·734 Board of Trade units.

Energy in Watt-hours taken from Secondary Circuit.

11	×	0	=	0
5	×	2,400	=	12,000
4	×	3,000	=	12,000
3	×	6,000	=	18,000
1	×	18,000	=	18,000

Total = 60·000 Board of Trade units.

It will be seen, therefore, that the total Board of Trade units given in the primary circuit in the 24 hours are 68·734, and the total Board of Trade units taken from the secondary circuit in 24 hours are

* See "Experimental Researches on Alternate Current Transformers," by J. A. Fleming. "*Proceedings* of the Institution of Electrical Engineers," November, 1892.

60 000. The secondary output is, therefore, 87 per cent. of the primary intake, and this is called the all-day efficiency of the transformer on that old diagram. It is not very far from the instantaneous or actual efficiency of the transformer at one-tenth of full load. It will generally be found that the actual efficiency at one-tenth of full load is a very fair guide to the all-day efficiency on a load having a load factor of 10 per cent. One thing that should be noticed in connection with this part of the subject, is that the iron core losses in the transformer are diminished as the transformer heats up. The curve in fig. 42 shows the results of an experiment with a 50 kilowatt transformer. The transformer was taken up when perfectly cold, and its core loss was measured and found to be 983 watts. This transformer was then connected with the circuits, and the core loss was taken at various intervals during a period of 20 hours, until the transformer had reached a final constant temperature. It was then found that the iron core loss had fallen to 893 watts. The transformer was then disconnected from the circuit, and allowed to cool, observations being taken during that period. After 24 hours the transformer had again become quite cold, and the core loss had risen up to 983 watts. There is, therefore, a difference of 100 watts, or nearly 10 per cent. in the core loss of the transformer when taken hot and when taken cold. This experiment shows the necessity for defining the conditions under which the core loss and efficiency of a transformer shall be taken; it is not enough to specify simply that the efficiency shall be of a certain value. It must be specified under what conditions this efficiency is to be taken, whether with the transformer cold, or the transformer warm. In addition to this there is a variation of the iron core loss taking place with time. When a new transformer, which has never before been used, is connected with the circuits, it is often found that when core loss measurements are made continuously at regular intervals, the core loss goes on increasing, and this may take place to the extent of 40, 50, or even 100 or more per cent. increase. In fact, instances have been noticed in which a core loss has increased in the course of a few months to three times its original value. Mr. Mordey found that he could produce this effect in iron by slow heating. It does not occur in all transformers. In an experiment I specially tried with two new Thomson-Houston 30-kilowatt transformers, which were connected to the circuits night and day for three months, and regularly measured at intervals, no apparent increase in the core loss was found. The reasons for this permanent increase in the hysteresis loss are not yet entirely explained. In the case of some iron which has been very carefully annealed, it is found there is a remarkable rise in the hysteresis loss when this iron was used as the core of a transformer. The same rise is also found in the case of iron which has not been very carefully annealed. We cannot at the present moment state precisely what are the conditions under which this increase in core loss takes place, or what is the constituent in the iron that tends to produce it. It has been supposed by some investigators that the presence of silicon in the iron has a tendency to determine this increase in the hysteresis loss, as the iron is magnetically used. It, however, points to the necessity not only of testing transformers at first, when they are purchased, and before accepting, but of taking a series of tests of the transformer at regular intervals. Suppose that in a sub-station there are three or four large transformers, and that one of these transformers is made the master transformer, and is kept connected with the circuits night and day, the others only being switched on during the time of heavy demand; then it is obviously a very important matter that the transformer, which is thus made the master transformer, should be the one which has the least core loss; and if it should happen that this transformer is one which has largely increased its core loss by use, then it should be exchanged for another which has the least obtainable core loss for that size of transformer. In every sub-station the watt-meter arrangement described at the beginning of this lecture should be capable of being set up in order to make core-loss measurements in a systematic manner. It is perfectly clear that if a few thousand Board of Trade units more than necessary are being wasted in each transformer sub-station, that the total value of these Board of Trade units when added up and capitalised may realise a very considerable sum of money.

For the purpose of testing large transformers in workshops without requiring a large consumption of power, Dr. Sumpner has devised a differential method of testing, the arrangements of which are shown in the diagram in fig. 43. In this case the power given out by one transformer on the secondary side is put back into the primary circuit by means of another reverse transformer, so that what is actually taken from the primary mains is merely the total loss in the two transformers. This total loss is measured by a wattmeter arrangement, which enables us to measure, therefore, the efficiency of the two transformers taken together, and, therefore, if they are identical, the efficiency of either of them. In addition to the efficiency tests, there ought always to be a series of security tests to test the strength of the transformer. In the first place, the temperature should be taken after the transformer has been connected to the mains for 24 hours on open circuit, and then connected to the mains for two hours on full secondary load. This temperature is best taken, as described in the beginning of the lecture, by measuring the resistance of the copper circuits, but it may be checked by means of a thermometer placed inside the case. Under no circumstances should the temperature in the interior of the transformer rise above 100° C. In the next place, electric pressure equal to double the primary pressure ought to be put on between the primary and the secondary circuits for at least 15 minutes, and the same double pressure ought to be put on between the primary and case—that is to say, if the transformer works at 2,000 volts on the primary circuit, 4,000 volts should be put on between the primary and secondary circuit for 15 minutes, and 4,000 volts between the primary and case for 15 minutes. In addition to this, the transformer should be tested for several hours at the normal pressure before being put to work. In the case of large transformers which have stood idle for some time, it is not wise to put on the full primary pressure at once. The transformer should be gradually warmed up by passing a large current through the secondary circuit of the transformer, the primary circuit being short-circuited. In that manner the transformer will be gradually heated up, any moisture which has been absorbed into the insulating material or into the case will be got rid of, and the transformer will be gradually brought into a condition of high insulation. Transformers which have been standing in the stores for a long time may frequently fail if put suddenly on to the working circuits without some such precaution.

Next, with regard to magnetic leakage, it is important to employ some test to ascertain whether there is a large magnetic leakage. Magnetic leakage, as already explained, is due to an escape of induction, linked with the primary circuit, and which does not entirely pass through the secondary. It is promoted by any separation of the primary and secondary coils, as in fig. 44, but is not entirely eliminated by any arrangement of them, as may be seen by considering the diagrams in fig. 45. This leakage, of course, can be ascertained by measuring the secondary drop as described above, and comparing that value with the total copper drop as calculated by the rule already given. An experimental proof of magnetic leakage can be obtained by a simple method due to Mr. Mordey. Two thermometers are taken, one filled with mercury, and the other filled with alcohol. These thermometers are compared to see that they are in agreement at the ordinary temperature. The bulbs of the thermometers are then introduced into any portion of the transformer near the secondary coils and kept there for some time. If there is any leakage of magnetic induction outside the secondary circuit, this induction passing through the mercury thermometer will generate heat in the mercury and cause the mercury thermometer to rise, but the spirit thermometer will be unaffected by this process. Hence, although both thermometers will rise from external temperature, if the mercury thermometer rises more than the spirit thermometer it indicates the presence of magnetic leakage at that spot where the bulbs are placed. In some transformers magnetic leakage is actually encouraged. A transformer, designed by Elihu Thomson, intended to give constant currents from the secondary circuit when the primary circuit is worked off a constant potential circuit, is constructed as shown in fig. 46. In this case there is a kind of iron bridge, interrupted by an air gap across the core between the primary and secondary circuit; and across this bridge, or air gap, induction is forced as the secondary current increases. This leakage, therefore, diminishes the electromotive force in the secondary circuit, and that effect tends to keep down the secondary current, and hence, to preserve it at a constant value. Such a transformer can, therefore, be employed to work arc lamps in series off a constant potential primary circuit. The secondary drop is found to be affected to some degree by the nature of the alternators on which the test was made. A peaked primary E.M.F. curve gives a greater leakage drop than one with a more rounded form. In general, however, magnetic leakage is a thing to be discouraged, and every specification for transformers ought to contain a clause defining and limiting the amount of secondary drop. One convenient way of doing this is as follows:—Suppose the standard secondary electromotive force to be 100 volts, and the primary electromotive force 2,000 volts, then the specification should define that when the transformer is working on a constant potential primary circuit of 2,000 volts, the secondary terminal potential difference on the transformer should be 100 volts at half load. At full load the secondary potential difference should not be less than 98½ volts, and at no load should not be greater than 101½ volts. In this manner the unavoidable secondary drop is, as it were, distributed half up and half down, and is not so much felt on the lamps as if the transformer

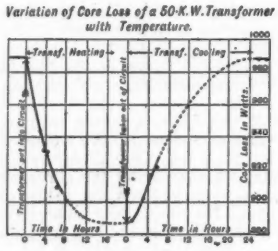

Variation of Core Loss of a 50-K.W. Transformer with Temperature.
Transf. Heating
Transf. Cooling
Time in Hours
Time in Hours
Core Loss in Watts.

FIG. 42.

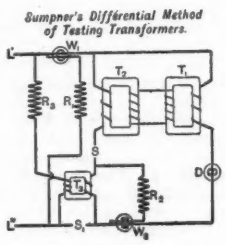


FIG. 43.

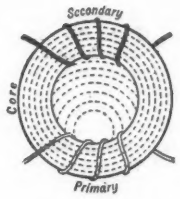


FIG. 44.

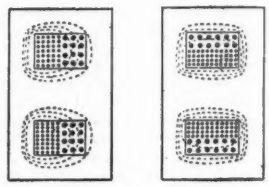
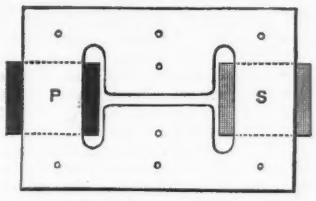


FIG. 45.

gave its standard electromotive force at no load, and then experienced the full effect of the drop when loaded up to full load. Also in a specification for transformers the manufacturer ought never to be allowed to produce a high efficiency at the expense of a large secondary drop, but such a definition of the core loss and copper loss ought to be given that he is bound to produce an all-round excellence. As a sort of guide to the kind of figures which may be obtained by good makers in actual practice, the following table may be taken as representing the secondary drop and core loss in transformers of these various sizes. These figures may be taken as a kind of indication of the core loss and secondary drop, which can be obtained in good modern practice in the construction of transformers. Some



Thomson-Houston, constant potential to constant current, transformer.

Fig. 46.

makers may be prepared to do better than this; but exceedingly small iron core losses ought always to be looked upon with a certain amount of suspicion, the important question being, not how low can the iron losses be made, at first, but how long will they keep low when the transformer is being used; and this, as above stated, can only be determined by careful tests, made at intervals, as the transformer ages:—

Size of transformer defined by full secondary output in watts.	Allowable iron core loss on open secondary circuit in watts.	Allowable secondary drop in per cent. of normal secondary electromotive force.
750	20 to 23	3
1,500	36 „ 41	3
2,250	43 „ 50	3
3,000	49 „ 57	3
3,750	62 „ 71	3
4,500	65 „ 74	2¾
6,000	75 „ 87	2
7,500	88 „ 101	2
9,000	105 „ 121	2
10,500	115 „ 133	2
12,000	121 „ 139	2
13,500	138 „ 155	2
15,000	150 „ 172	2

WAGES AND HOURS OF LABOUR.

The second annual report of the Labour Department of the Board of Trade has been issued. It takes one only to the end of 1894, except as regards a few preliminary figures for 1895. It resembles the application of mathematics to many engineering problems, showing why certain things are possible after they have been proved so by the more ignorant. So will this report, it comes too late for any serious use to be made of it. But it contains a great mass of figures, and shows how Tom Smith and Bill Jones have earned a ½d. a week less in one year than another. Such an amount seems trivial, and the whole report is crammed with such trivialities. But to many million Smiths and Jones these trivial items are more or less serious, and may easily mean a variation of 3 per cent. in wages, and when pay is small and spent so largely on absolute necessaries, a shilling is not to be despised. But one may grow sentimental over these simple annals of the poor and all the sentiment in the world will not relieve the figures of their dulness or justify their late publication, if they are of real value, as we suppose they must be to the statistician, and perhaps others. Averages are perhaps all very well for the statistician, and as an average the weekly wage of nearly 1½ million people investigated was raised 5½d. in the year 1893. In 1894, again, about twelve hundred thousand people suffered a reduction averaging 16½d., and again in 1895 over a million people averaged a loss of 16½d. Thus it happens that a net rise of £12,426 per week in 1893 was replaced by a decrease of £45,000 in 1894, and probably a further decrease of £30,000 in 1895. Yet in spite of this, the average percentage of unemployed members of trade unions reporting to the Labour Department is in the three years 7·5, 6·9 and 5·8, showing at least a better distribution of wages. Curiously, all three years show great prosperity in the building trades. As to the reductions, it is almost wholly in the mining section that the lowering of the earnings is shown. Can not this be attributed to the strike, and is it not a proof how valueless in a sense such reports as this are apt to be. A portion of the decreased wages appears to be due to a shortening of hours, or may, at least, by some people be attributed to this cause. There is much room for argument on this score. Reports from firms who have tried the eight hours' day would seem to show that there is no reason for less pay to accompany fewer hours. Even at Brunner Monds, where a reduction of the day from 12 hours to 8 might at least warrant such an expectation, the labour cost per ton of product come out less. But perhaps this is no criterion. A twelve hour day is so very exhausting that it might be argued that anything would be better and more economical down to nine hours, and that a cut from nine hours to eight hours would show a worse result. At Brunner Monds eight hours was almost compulsory, just as twelve had been, both being even divisions of the solar day. But at Messrs. Allans, of Sunderland, and at Mather & Platt's, we believe eight hours has been proved better than nine, and if this can be shown to be really the case in a few more instances, it would seem to be folly to work longer hours merely on the principle which actuated a Manchester firm to dismiss their best man because they could not think of allowing one of their servants to earn several thousands a year, and so they dismissed him, and themselves ceased to make a profit on his department. The idea of a servant having more than a rag and a crust, is so distasteful to some men who like to figure largely in charitable lists that they do frequently suffer seriously in pocket in carrying out their selfish ideas, and scores of employers would rather earn a thousand pounds on a ten hours' day than make eleven hundred pounds on a day of nine hours.

It appears that about 8,000 persons have been put on 48 hours per week apart from Government employés. These are comprised in 42 various works, of which one works—a cabinet makers—reverted to 51 hours in a few months. These were works in Scotland employing 80 hands, or less than one per cent. of the total number of people affected. Opponents of the nine hours' system, when introduced, would have it that the hour saved would be wasted in drink. This has not proved to be the case, and therefore it must have had a beneficial effect on the physique of the mass of the people. The writer's observations are all to the effect that the workers of this country are more sober than they were, and statistics we believe confirm this. So far as tea is indicative of sobriety, the same habit is extending, and it would astonish men of twenty years ago could they see the change that has come over the country, not so much in the way of a maudlin teetotalism, as in that of all round moderation. So far, however, there is no specially wide evidence that an eight hour day would prove better than a day of nine hours. At the same time the experiments so far tried are strongly indicative that the results are equally good; once prove even an equality and the sense of the shorter day would soon be recognised.

NEW PATENTS AND ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Compiled expressly for this journal by* W. P. Thompson & Co., *Electrical Patent Agents*, 322, *High Holborn*, *London*, *W.C.*, *to whom all inquiries should be addressed.*]

NEW PATENTS.—1896.

16,019. "Improvements in regulating switches." R. E. B. Crompton and E. A. N. Pochin. Dated July 20th.

16,057. "Improvements in electrolytic apparatus." C. Kellner. Dated July 20th.

16,091. "Improvements in electric batteries." A. Stephens and F. Puttaert. Dated July 21st.

16,152. "Apparatus for controlling electric currents." J. Estrade. Dated July 21st.

16,231. "Improvements in electric motors and dynamos." G. Seymour and S. A. Letts. Dated July 22nd.

16,256. "Improvements in electric furnaces." L. M. Bullier. (Date applied for under Patents, &c., Act, 1883, Sec. 103, December 28th, 1895, being date of application in France.) Dated July 22nd.

16,257. "Improvements in electric furnaces." L. M. Bullier. (Date applied for under Patents, &c., Act, 1883, Sec. 103, January 27th, 1896, being date of application in France.) Dated July 22nd.

16,268. "Improvements in electric batteries." W. Rowbotham. Dated July 22nd.

16,270. "Improvements in secondary electric batteries." M. O. A. Garreau. Dated July 22nd.

16,326. "Improvements in apparatus for obtaining electric discharges." F. W. Golby. (Alexander Vosmaer, Holland.) Dated July 23rd.

16,342. "Improvements in or relating to prepayment mechanism for electrical or other meters." C. O. Bastian and H. C. Hodges. Dated July 23rd.

16,358. "Improvements in or in connection with electric railways or tramways." H. J. Gill. Dated July 23rd.

16,373. "Improvements in the distribution of electricity, and in junction boxes for use therein." W. Illingworth and T. Smith. Dated July 24th.

16,404. "Improvements in and relating to electrical signalling apparatus or bells." S. Jevons and W. Collins. Dated July 24th.

16,418. "Improvements in the method of and means for automatically regulating arc lamps and other electrical apparatus." W. de Graaff. Dated July 24th. (*Complete.*)

16,421. "Regulator for dynamo machines." A. Heusch and P. Brandt. Dated July 24th. (*Complete.*)

16,435. "Improvements in filaments of electric incandescent lamps." F. E. W. Bowen. Dated July 24th.

16,445. "Apparatus for controlling electrically actuated railway point apparatus." Siemens Bros. & Co., Ltd. (Siemens & Halske, Germany.) Dated July 24th.

16,457. "Improvements in solenoid cores for voltmeters." P. Brandt and A. Heusch. Dated July 24th. (*Complete.*)

16,475. "Improvements in electric arc lamps." E. Jones, A. E. Jones, and G. Kynoch & Co., Ltd. Dated July 25th.

16,502. "Improvements in and connected with electric clocks." W. Whitehead. Dated July 25th.

16,514. "Improvements in electrical switches." W. J. Davy. Dated July 25th.

16,516. "Improvements in accumulator batteries." J. Vaughan-Sherrin and H. H. Sherrin. Dated July 25th.

16,533. "Improvements in filaments for electric glow lamps and in methods of manufacture of the same." F. de Mare. (Date applied for under Patents, &c., Act, 1883, Sec. 103, January 28th, 1896, being date of application in France.) Dated July 25th.

16,534. "Improvements in filaments for use in electric glow lamps." F. de Mare. Dated July 25th.

16,539. "Improvements in the manufacture of cables for telephonic, telegraphic, electric lighting, and other electrical purposes." P. Ormiston and S. B. Apostoloff. Dated July 25th.

EXPIRING PATENTS.—1882.

We are informed by Messrs. W. P. Thompson & Co. that about 83 applications for electrical patents were filed in the month of August, 1882. Only three of the patents granted on these applications have been maintained to run their full length of term, and as they are of considerable interest, we give abstracts of them below:—

3,842. "Improvements in suspending telegraph wires from iron posts." H. C. Jobson. Dated August 11th, 1882. Instead of providing the posts with iron brackets to support the insulators, they have wooden arms for that purpose, to prevent electrical leakage when the insulators are broken. Each arm consists of a bar of wood about 2 feet long, and it has holes or sockets to receive the stem of the insulators. Two bolts are passed through the arm and through an iron plate which has a flange upon its underside for the wooden arm to lie upon. The plate has also ribs or projections upon it, and when the arm is applied the projections take a steady bearing against the post. The bolts also pass through a back piece applied upon the further side of the post. When the nuts are screwed up against washers upon the outer side of the arm, the whole of the parts are drawn tightly together, the post is nipped, and the wooden arm is securely held to the post. 2 claims.

3,882. "Improvements in telephonic apparatus." F. R. Welles. (C. E. Scribner and W. R. Pattinson, United States.) Dated August 15th, 1882. The first part of the invention relates to modifications in apparatus for telephone exchange at the central office at which multiple switchboards are connected to complete metallic circuits. A plug is used in the switch, having as contact pieces a central point and an external ring, in connection with the poles of a battery. By pressing the plug against a test key the key-lever breaks contact with a screw and makes contact with a skid connected to a short circuiting wire, thus shunting the electro-magnet of the annunciator. The method of operating is explained in other respects and the construction of the switches and manner of insulating certain of thin parts are described and shown. "Any two of the metallic circuits may be formed into one for conversation by inserting the double pointed terminal plugs of a double flexible conducting cord in the switches respectively of said circuits upon either of the multiple boards." Another part relates to the transmitting arrangements. One battery applied by a Wheatstone bridge or balance serves for several stations. The coils of the transmitting telephone form a side, or sides, of the bridge, and the primary of one induction coil forms the cross connection; the secondary is in the line circuit. One mouthpiece is common to the two transmitters which are in close proximity, that the respective vibrations of the diaphragms may be synchronous. The battery may be at the central office or otherwise. A single transmitter may be used in one arm of the bridge, and the other arms may be balanced by resistance coils; but this arrangement is less effective than the former. The receiving or operator's telephone has its coil in a local battery circuit "and the current is rendered undulatory by induction." It may also be used as a transmitter, but is preferably placed in circuit with a transmitter or microphone. The telephone has an iron diaphragm in front of a soft iron core, surrounded by a coil of four or five ohms resistance in circuit with a battery. An induction coil is of two windings, one of low resistance in circuit of the battery, and the other of high resistance (preferably about 150 ohms), insulated in the circuit of the telephone line. When undulating currents occur in the line passing through the high resistance winding like undulatory currents are reproduced in the other winding and the induced currents find circuit through the telephone magnet coil, the tension of which is thus varied, and the diaphragm caused to vibrate. It is stated that the telephone may be worn as a head telephone. Lastly, a microphone-transmitting telephone is described in which the contact consists of a metallic point supported by a spring and a carbon piece at the free end of a loaded yielding support, and the improvement consists in an adjustable stop, preferably of soft rubber placed by the side of the weighted support of the carbon opposite the metallic point, and so adjusted as not to interfere with the vibration of the electrodes, yet so near as to keep the loaded carbon piece from moving far enough to break contact with the metallic point. This arrangement presents loss of contact when the instrument is influenced by loud sounds. 6 claims.

3,991. "Incandescing conductors for electric lamps" T. J. Handford. (T. A. Edison, United States.) Dated August 19th, 1882. The object of the invention is to obtain flexible carbon filaments having a specifically high resistance. An oxidised drying oil as linseed, cotton seed, or nut oil mixed with any other carbonisable material (as ditolye resins, carbohydrates, or albuminoid substances) may be moulded or pressed into filaments, or may be formed into a tough flexible sheet by drying and baking. The filaments may be cut with enlarged ends before or after carbonisation. When the oil or mixture is formed into sheets, it is spread on smooth metal plates to be dried and baked, and the plates are then eaten away by an acid to enable the membrane to be detached. The plates may be of glass or mica which can be attacked by hydrofluoric acid, or of gelatine which may be dissolved by water. Instead of drying oil the gluten of cereals with or without a portion of starch may be used as material for the filaments which are punched of the desired shape, and with enlarged ends from the dough, or the dough may be pressed through an orifice in a chamber and suitable lengths be cut off. Such lengths are enlarged at the ends by attaching pieces of dough for clamping. The carbonisation is effected in this as in the former process "by heat under steam pressure." 2 claims.

ABSTRACTS OF PUBLISHED SPECIFICATIONS.

[*Copies of any of these Specifications may be obtained of* Messrs. W. P. Thompson & Co., 322, High Holborn, W.C., *price, post free,* 8½*d.* (*in stamps.*)]

1895.

8,306. "Improvements in or connected with electric batteries." C. P. Shrewsbury, F. L. Marshall, J. Cooper, and J. L. Dobell. Dated April 26th, 1895. Relates to that class of batteries in which the positive electrode is composed of carbonaceous material and the negative electrode of iron, &c. The improvement consists in suspending from the lid or cover of the battery, porous cells or pots in which are arranged the carbon electrodes. A sufficient space must be provided between the lower end of the pot and the bottom of the cell to admit of the circulation of the fused salt. 1 claim.

9,967. "Improvements in electric regulation." H. N. Moody. Dated May 20th, 1895. This regulator comprises a spindle on which is mounted a sleeve carrying a disc and two reversed cones, all rotated in one direction by a motor. The sleeve and parts are moved longitudinally on the spindle by two solenoids, and in an opposite direction by any suitable force so that the coned follower will be engaged and driven in opposite directions as required, and the desired movements transmitted by its spindle to the mechanism to be regulated. 3 claims.

10,433. "Improvements in dynamo electric generators." G. E. Dorman. Dated May 27th, 1895. Consists in forming a generator of two castings, bolted together, and containing two pole pieces having exciting coils around them, said pole pieces having end brackets cast on them, one or both ends of the casting being completely enclosed by the brackets which are made as thin as possible. One of the castings is made in sections. 3 claims.

10,538. "Improvements in dynamo-electric generator." G. E. Dorman. Dated May 28th, 1895. An improvement on patent 6,569 of 1889, which consists in omitting the upper half tube or casting and replacing it by a plate of iron manufactured in sections. These plate sections may be screwed on, the machine being enclosed by extremely thin ends, so that few lines of force can pass through them. Other improvements are described. 3 claims.

1896.

2,682. "An improvement in multiple contact circular electric switches." Siemens Bros. & Co., Limited, and F. H. Kingdon. Dated February 18th, 1896. Relates to a multiple contact circular electric switch, having on its brush axis a wheel with notches and hollows in its periphery engaged respectively by a pin or tooth. A boss on the axis of the handle is connected to the switch in such a manner that the operator effects by each complete turn of the handle the movement of the brush over only one step or division of its path and there locks it, and, consequently, must make as many turns as there are steps over which the brush is to pass from one contact to another. 1 claim.

3,091. "Improvements relating to the composition of the filling paste of accumulation batteries." R. Linde. Dated February 11th, 1896. Relates to a substance for effectively binding together the particles of lead oxides of the filling paste of accumulation batteries, which consists in kneading together the lead oxides with the bodies of the family of bitter principles such as aloine, C 16 H 18 O, either in solution in water, or alcohol or ether. 1 claim.